VOLUME 14 PART 5

MEMOIRS
OF THE
QUEENSLAND MUSEUM

BRISBANE

VOLUME 14 PART 5

MEMOIRS
OF THE
QUEENSLAND MUSEUM

ISSUED BY THE AUTHORITY OF THE MINISTER FOR EDUCATION,
THE HON. J. C. A. PIZZEY

CONTENTS

☆ ☆

VOLUME 14 PART 5

(Issued 28th February, 1966)

THE TYPE SPECIMENS OF SOME OF DE VIS' SPECIES OF FOSSIL MACROPODIDAE

ALAN BARTHOLOMAI

Queensland Museum

During the past decade, interest in the extinct marsupials of Queensland has increased tremendously, and publications by Woods (1958) and Bartholomai (1962, 1963) have clarified the taxonomy, stratigraphic position, and morphology of several of the genera previously discussed by De Vis (1895) as macropodids. Although the present paper does not complete the revisionary work, it has been felt desirable to publish descriptions and figures of the type specimens of the remainder of De Vis' (1895) species of Macropodinae in the collections of the Queensland Museum.

Unfortunately, De Vis' (1895) descriptions are often inadequate and difficult to interpret, his figures are generally poorly executed, and he did not designate holotypes for many of his species. Consequently, every attempt has been made to select name-bearing specimens from the original series which will give stability to the nomenclature, and where possible, clarify the stratigraphic position of the species involved. Such selection is also a necessary step to future revisionary work on Queensland fossil Macropodinae.

The species to be considered were originally referred by De Vis (1895) to the genera *Halmaturus* Illiger and *Macropus* Shaw. The "*Halmaturus*" group included those macropodines in which the permanent premolar was retained throughout life, while in the *Macropus* group the permanent premolar was shed during progression of the tooth row. While it is likely that the name "*Halmaturus*" cannot be applied to any of De Vis' species, it has been considered convenient to retain De Vis' nomenclature in the present paper. It is believed that future studies will confirm that each of De Vis' groups includes more than one genus.

The collections of the Australian Museum, National Museum, Western Australian Museum, South Australian Museum, and Tasmanian Museum and Art Gallery have been checked for missing type material and the assistance of these institutions is gratefully acknowledged.

All photographs are natural size, and all measurements are in millimetres.

"HALMATURUS" DRYAS De Vis

(Plate 15, figures 1–3)

Halmaturus dryas De Vis, 1895, Proc. Linn. Soc. N.S.W., 10 (n.s.), pp. 109–111.

LECTOTYPE.—F.3582, partial right maxilla with P^3–M^3, adult, ?Chinchilla, S.E.Q., ?Chinchilla Sand, probably Pliocene (figd. in part, De Vis, 1895, pl. 17, figs. 13, 15).

MEASUREMENTS OF LECTOTYPE.—P^3, 13·2 x 6·6; M^1, 9·7 x 8·2; M^2, 12·1 x 9·3; M^3, 13·8 x 10·1.

DESCRIPTION OF LECTOTYPE.—P^3 elongate, subtriangular in basal outline, broader posteriorly. Crown with high longitudinal crest, slightly concave labially, transected by three sets of vertical ridges, with production of cuspules at crest. Low lingual crest descending anteriorly from moderately high hypocone, becoming nodular mesially with production of three well-defined tubercles, disappearing on lingual base of crown below first cuspule posterior to paracone; crests separated by narrow, shallow, lingual basin. Strong ridge connects hypocone antero-labially to below metacone, while lesser ridge from hypocone unites labially with posterior extension of longitudinal crest, delimiting posterior fossette. Labial base of crown tumescent and nodular.

$M^1 < M^2 < M^3$; molars subrectangular, slightly constricted across median valley; lophs moderately high, anteriorly bowed; metaloph broader than protoloph in M^1, protoloph broader in M^2 and M^3. Anterior cingulum relatively low and narrow, moderately short; well-defined, strong fore-link passes posterioly from near mid-point of anterior cingulum to centre of protoloph; extremely slight ridge descends anteriorly from paracone; posterior ridge from paracone into median valley stronger. Mid-link high, strong, descending postero-labially from protocone then posteriorly across median valley to mid-point of metaloph; slight ridge descends antero-lingually from metacone of M^3 into median valley. Lingual moiety of median valley V-shaped, labial portion sharply U-shaped. Strong postero-labial ridge descends from hypocone across mid-line of crown, meeting postero-lingual ridge from metacone above tooth base, with production of posterior fossette. Posterior surface of metaloph of M^3 mesially with two slight, vertical, accessory ridges.

In the description of "*Halmaturus*" *dryas*, De Vis (1895) stated "type maxillary", but he failed to indicate which individual of the referred maxillary series constituted the holotype. Only four maxillae were originally referred to the species, including the right maxilla partially figured (De Vis, 1895, pl. 17, figs. 13, 15). The basal breadth of P^3 of this specimen was recorded as 7·8, a measurement apparently in error. As this specimen represents the best preserved of the maxillary remains, it has been selected as lectotype. The figured M^3 (De Vis, 1895, pl. 17, fig. 15), was poorly illustrated, but there is little doubt that M^3 of the lectotype is represented.

"HALMATURUS" INDRA De Vis

(Plate 15, figures 4–6)

Halmaturus indra De Vis, 1895, Proc. Linn. Soc. N.S.W., 10 (n.s.), pp. 112–113.

HOLOTYPE.—F.3595, partial left mandibular ramus with P_2–M_1 (unerupted P_3 removed by fenestration and no longer in the Queensland Museum collections), Darling Downs, S.E.Q. (figd. in part, De Vis, 1895, pl. 17, figs. 18, 20).

MEASUREMENTS OF HOLOTYPE.—P_2, 6·7 x 4·3 ; DP_3, 7·1 x 4·2 ; P_3, ——— ; M_1, 8·5 x 5·6.

DESCRIPTION OF HOLOTYPE.—P_2 relatively short, robust, subovate in basal outline. Longitudinal crest secant, curving lingually posteriorly, transected mesially by set of vertical ridges with production of cuspule at crest ; crown basally with labial and lingual tumescences, continuous around anterior margin, with production of small anterior basal cuspule.

DP_3 molariform, subtriangular in basal outline ; lophids moderately low, with hypolophid crest much broader than protolophid ; protolophid rectilinear, but hypolophid somewhat convex posteriorly. Trigonid basin narrow, extremely poorly developed labially, short, its length being much less than distance between lophids. Fore-link high, strong, descending anteriorly from protoconid to near mid-point of high anterior cingulum, ornamented labially and lingually by a set of weak accessory ridges ; antero-lingual fossette developed in trigonid basin in conjunction with slight anterior ridge from metaconid. Protoconid positioned almost on axis of crown. Posterior ridge from protoconid moderately strong, uniting with moderately strong mid-link descending antero-lingually from hypoconid ; posterior ridge from metaconid weak, descending into lingual extremity of rounded talonid basin ; labial portion of talonid basin much reduced and at lower level than lingual portion. Anterior ridge from entoconid weak. Posterior of hypolophid rounded, unornamented ; basally with slight postero-labial swelling.

M_1 subrectangular in basal outline, very slightly constricted across talonid basin ; labial lophid surfaces below protoconid and hypoconid slightly convex in anterior view. Lophids moderately high, with protolophid nearly rectilinear and with hypolophid moderately convex posteriorly ; hypolophid broader than protolophid. Trigonid basin relatively broad, and with its length almost equalling distance between lophids. Fore-link rather low, moderately strong, unornamented, descending antero-lingually from protoconid into labial moiety of trigonid basin, not united with relatively low anterior cingulum ; weak anterior ridge from metaconid unites with lingual limit of anterior cingulum with production of broad, slightly dished, almost horizontal lingual portion of trigonid basin ; labial portion of trigonid basin reduced. Very slight posterior ridge descends from metaconid to unite with equally weak anterior ridge from entoconid across lingual margin of almost horizontal portion of talonid basin. Mid-link from near hypoconid low, moderately strong, crossing talonid basin to base of protolophid, labiad to mid-line. Labial portion of talonid basin reduced. Posterior of hypolophid rounded, unornamented ; basally with slight postero-labial swelling.

De Vis (1895) referred only one specimen to "*Halmaturus*" *indra*. The specimen re-described as the holotype is the only juvenile mandibular ramus in the Queensland Museum collections which fits the description for the diagnostic P^2 of this species. This tooth also agrees well with the deciduous premolar figured by De Vis (1895, pl. 17, fig. 18), but the structure of the associated M_1 does not agree so well with the corresponding figure of De Vis (1895, pl. 17, fig. 20). It does show, however, a nearly rectilinear protolophid, in spite of De Vis' statement to the contrary.

Unfortunately, P_3 of the holotype, which was excavated and removed by De Vis, has been lost. DP_3 was not described in the original account. The measurement for the series, P_2–M_1, recorded by De Vis (1895) as 23·1 mm, is in error ; the correct figure is 21·3 mm.

As with many of the specimens described by De Vis (1895), the holotype lacks specific locality information. However the preservation suggests the Chinchilla Sand as the likely provenance.

" HALMATURUS " ODIN De Vis (nomen dubium)

Halmaturus odin De Vis, 1895, Proc. Linn. Soc. N.S.W., 10 (n.s.), pp. 111–112.

De Vis (1895) selected an adolescent right ramus with the first four cheek teeth as the holotype of " *Halmaturus* " *odin*. As no description or figure of deciduous dentition was presented at that time, it is apparent that the holotype, although juvenile, contained P_3–M_3, a conclusion supplemented by the fact that the figured P_3 (De Vis, 1895, pl. 17, fig. 16), shows no indication of wear. An exhaustive search of the collections of the Queensland Museum has revealed that the holotype is missing, and it is presumed to have been lost or destroyed.

There is only one record of a specimen of " *H.*" *odin* having been removed from the collections, and this relates to a young left mandibular ramus with M_1, which was forwarded to the Australian Museum on 25th November, 1895, at about the time of De Vis' revision. However, this specimen did not appear in the list of referred specimens and could not be confused with the holotype. Exchanges were also made with other Australian Museums at that time and personal checks of the collections of the National Museum and Western Australian Museum were made without success. The collections of the South Australian Museum and the Tasmanian Museum and Art Gallery also failed to yield the missing specimen.

Stirton (1957) attributed a series of measurements to the holotype of " *H.*" *odin*. These measurements refer to F.3589, an adult right mandibular ramus with P_3–M_4, originally referred to the species by De Vis (1895), but not the holotype.

None of the specimens at present in the Queensland Museum collections, originally referred to " *H.*" *odin*, can be reconciled with the diagnosis, description, or figures of De Vis (1895). In particular, the specimens lack any semblance of accessory processes on the antero-lingual surfaces of the lophids, considered by De Vis to be like those in *Sthenurus* Owen, and diagnostic of the species. Further, the peculiarly complex nature of the crest of P_3, as shown in his figure, is not duplicated in the referred specimens containing P_3.

Similarly no other specimen in the Queensland Museum collections can be referred to " *Halmaturus* " *odin* De Vis, and no taxonomic species can be identified. Consequently, the name of the nominal species should be regarded as a *nomen dubium*, a conclusion with which Mr. J. T. Woods, who has also examined the material in question, agrees.

" HALMATURUS " SIVA De Vis

(Plate 16, figures 4–6)

Halmaturus siva De Vis, 1895, Proc. Linn. Soc. N.S.W., 10 (n.s.), pp. 113-114.

HOLOTYPE.—F.2926, partial right mandibular ramus with P_3, M_2–M_4, adult, Darling Downs, S.E.Q.

MEASUREMENTS OF HOLOTYPE.—P_3, 7·2 x 2·8; M_1, ——; M_2, 9·2 x 5·6; M_3, 10·3 x 6·1; M_4, 10·9 x 6·3; mandible depth and breadth below M_2–M_3, 17·4 x 9·2.

DESCRIPTION OF HOLOTYPE.—Mandible moderately wide and shallow. Symphysis not ankylosed, elongate, set at a low angle of approximately 5° to base of mandible; geniohyal pit insignificant. Diastema long; ventral margin of ramus sharply rounded posterior to symphysis, becoming more broadly rounded posteriorly; mental foramen moderately large, oval, well anterior to P_3 and slightly below diastemal crest. Broad, rounded depression opening posteriorly into pterygoid fossa. Post-alveolar shelf short.

P_3 elongate, subtriangular in basal outline. Longitudinal crest secant, turning abruptly lingually in its posterior extension; crest transected by two sets of vertical ridges, but resultant cuspules along crest obliterated by wear. Well defined lingual ridge descends from posterior cuspid. Labial and anterior base of crown slightly tumid above roots, but only slightly swollen lingually.

$M_2 < M_3 < M_4$; molars subrectangular in basal outline, constricted across the talonid basin; lophids relatively high, moderately convex posteriorly; protolophid broader than hypolophid in M_2–M_4. Lateral surfaces of lophids nearly parallel, with labial surfaces only very slightly convex. Trigonid basin moderately broad, its length almost equalling distance between lophids. Fore-link high, strong, descending antero-lingually from protoconid, then anteriorly across trigonid basin to near mid-point of moderately low anterior cingulum. Labial moiety of trigonid basin forming moderately deep antero-labial fossette. Slight accessory ridge descends anteriorly from protolophid, close to fore-link, into trigonid basin in M_2. Strong, high mid-link descends antero-lingually from hypoconid, then curves antero-labially across talonid basin to unite with short ridge from posterior surface of protolophid close to mid-point. Lingual portion of talonid basin U-shaped, labial portion V-shaped; very slight ridge descends antero-labially from entoconid towards talonid basin. Posterior of hypolophid with feeble median vertical groove.

The holotype of "*Halmaturus*" *siva* (old registration number 11181) was designated in the list of specimens referred to this species by De Vis (1895). It lacks detailed locality data, but its preservation is typical of specimens derived from the Pleistocene fluviatile deposits of the eastern Darling Downs. The figures of the permanent lower premolar and of the third lower molar (De Vis, 1895, pl. 17, figs. 21–22) are rather poorly drawn, but it is considered likely that they represent parts of the holotype.

"HALMATURUS" THOR De Vis

(Plate 17, figures 1–3)

Halmaturus thor De Vis, 1895, Proc. Linn. Soc. N.S.W., 10 (n.s.), pp. 102–104.

LECTOTYPE.—F.3602, partial right mandibular ramus with P_3 exposed from above, M_1–M_3, M_4 erupting, juvenile, Ravensthorpe, Pilton, Darling Downs, S.E.Q., from Pleistocene fluviatile deposits (figd. in part, De Vis, 1895, pl. 17, fig. 2).

MEASUREMENTS OF LECTOTYPE.—P_3, 7·1 x 3·1; M_1, ——; M_2, 10·4 x —; M_3, 12·3 x 7·8.

DESCRIPTION OF LECTOTYPE.—Mandible strong, with ventral margin of ramus angular posterior to symphysis, becoming rounded posteriorly; labially with well defined groove below P_3 and M_1; lingually with broad, shallow depression opening posteriorly into pterygoid fossa; anterior margin of coronoid process inclined at approximately 80° to base of mandible.

P_3 relatively short, subovate in basal outline. Longitudinal crest divided by prominent median vertical grooves; posterior moiety transected by a set of vertical ridges with production of a cuspule at crest. Posteriorly, crest swings slightly lingually. Base of crown slightly tumescent.

$M_1 < M_2 < M_3$; molars subrectangular, slightly constricted across talonid basin; lophids moderately high, somewhat convex posteriorly; protolophid slightly broader than hypolophid in M_3. Trigonid basin moderately broad, its length almost equalling distance between lophids. Fore-link high, strong, descending from protolophid anteriorly to near mid-point of anterior cingulum; cingulum moderately high. Well defined antero-labial fossette developed in labial moiety of trigonid basin; extremely slight ridges descend anteriorly and posteriorly from metaconid towards trigonid and talonid basins respectively. Mid-link from hypoconid high, strong, crossing talonid basin to near mid-point of protolophid. Lingual moiety of talonid basin with variable accessory link in M_3 and M_4, close to mid-link; very slight antero-labial ridge descends from entoconid, into talonid basin. Posterior surface of hypolophid curved, with shallow, vertical, mesial groove near base; base of M_3 postero-labially with weak cingulum.

In the description of "*Halmaturus*" *thor*, De Vis (1895) failed to designate a holotype, and the lectotype selected is one of the most completely preserved representatives of the referred series.

De Vis (1895) places great importance on the permanent premolar as a means of distinguishing the species, and although the P_3 of the lectotype is somewhat smaller than indicated by De Vis in his text, it agrees with the description and is almost certainly that figured (De Vis, 1895, pl. 17, fig. 1).

The short original description is somewhat anomalous with respect to M_3, in that De Vis states that the posterior surface of the hypolophid is without a groove or posterior cingulum and has weak links, but his illustration shows a distinct posterior groove and relatively strong links and agrees with the structure presented in M_3 of the lectotype.

"HALMATURUS" VINCEUS De Vis

(Plate 17, figures 4–6)

Halmaturus vinceus De Vis, 1895, Proc. Linn. Soc. N.S.W., 10 (n.s.), pp. 100–102.

LECTOTYPE.—F.3577, partial left maxilla with P^3–M^4, adult, Kings Creek, Clifton, Darling Downs, S.E.Q., from Pleistocene fluviatile deposits.

MEASUREMENTS OF LECTOTYPE.—P^3, 13·4 x 7·6; M^1, 10·1 x 9·0; M^2, 11·8 x 10·3; M^3, 14·4 x 11·1; M^4, 13·7 x 11·4.

DESCRIPTION OF LECTOTYPE.—P^3 subtriangular in basal outline, robust. Longitudinal crest somewhat concave labially, moderately low, transected by three broad, low, vertical labial ridges; corresponding lingual ridges very reduced. Ridge descends lingually from metacone to position of hypocone; posterior ridge from hypocone forming posterior cingulum and postero-lingual basin, but greatly reduced by attrition; anterior ridge from hypocone forming well-defined, but worn, lingual cingulum to below paracone. Lingual basin posteriorly broad, anteriorly narrow. Labial base of crown somewhat tumescent.

$M^1 < M^2 < M^3 = M^4$; molars subrectangular, only very slightly constricted across median valley; lophs moderately low, anteriorly bowed with metaloph broader than protoloph in M^1 and slightly narrower in M^2–M^4. Anterior cingulum low, broad, but not as broad as the protoloph, short; very low fore-link passes anteriorly from base of protoloph to anterior cingulum, well labiad to axis of crown, accompanied by occasional variable accessory links; slight ridge descends anteriorly from paracone to labial extremity of cingulum, delimiting very slight antero-labial fossette. Strong moderately low mid-link descends postero-labially from protocone then posteriorly to unite with extremely short ridge from near mid-point of metaloph above median valley; low postero-lingual ridge from paracone forming shelf-like area below protoloph crest in unworn teeth; shelf-like area ornamented by low accessory ridges. Labial and lingual moieties of median valley broadly U-shaped. Strong ridge descends postero-labially from hypocone to form postero-labial fossette above base of crown; slight ridge descends postero-lingually from metacone into postero-labial fossette, forming shelf-like area below metaloph crest; shelf-like area ornamented by low accessory ridges in M^3, but unornamented in M^4. Lingual base of crown, particularly below protocone, somewhat tumescent in all molars, but less so in M^4.

No holotype was designated by De Vis (1895) in his description of "*Halmaturus*" *vinceus*, necessitating the selection of a lectotype from the original series of referred specimens. In his text, De Vis states that P^3 is unknown in the maiden state, but figures a permanent upper premolar showing no indication of wear (De Vis, 1895, pl. 16, fig. 12). This specimen could not be located in the collections of the Queensland Museum, and owing to the poor illustrative technique, none of the other specimens figured at that time (De Vis, 1895, pl. 16, figs. 13–15), could be separated from the large series of originally referred remains.

The partial maxilla selected as lectotype was one of the three original maxillary specimens possessing P^3–M^4. The length of this full series of cheek teeth is 60·0, corresponding to the lower limit quoted by De Vis (1895) for the three specimens in his possession.

"HALMATURUS" VISHNU De Vis

(Plate 16, figures 1–3)

Halmaturus vishnu De Vis, 1895, Proc. Linn. Soc. N.S.W., 10 (n.s.), pp. 114–116.

LECTOTYPE.—F.3860, partial right mandibular ramus with P_3–M_4, adult, Darling Downs, S.E.Q. (figd. in part, De Vis, 1895, pl. 17, figs. 3–4).

MEASUREMENTS OF LECTOTYPE.—P_3, 10·1 x 4·1; M_1, 7·8 x —; M_2, 9·4 x 6·5; M_3, 10·4 x 7·5; M_4, 10·7 x 7·3; mandible depth and breadth below M_2–M_3, 16·1 x 7·8.

DESCRIPTION OF LECTOTYPE.—Mandible narrow, rather shallow. Symphysis not ankylosed, set at low angle of approximately 5° to base of mandible; geniohyal pit very shallow, below anterior margin of P_3. Ventral margin of ramus rounded. Mental foramen moderately large, oval, well anterior to P_3, and just below diastemal crest. Ramus with shallow labial groove from below P_3 to below centre of M_3. Lingually, broad depression leads posteriorly to pterygoid fossa. Post-alveolar shelf short, leading to mesial wall of coronoid process.

P_3 elongate, suboval in basal outline. Longitudinal crest secant, transected by three major and one minor set of vertical ridges with production of cuspules at crest; base of crown markedly tumescent, produced to form noticeable cingulum anteriorly.

$M_1 < M_2 < M_3 = M_4$; molars subrectangular, slightly constricted across the talonid basin; lophids relatively low, almost rectilinear, with hypolophid somewhat more convex posteriorly; protolophid almost as broad as hypolophid in M_2, but much broader in M_3 and particularly so in M_4. Lateral surfaces of lophids markedly convex. Trigonid basin broad, its length almost equalling distance between lophids; fore-link low, moderately strong, unornamented, descending antero-lingually from protoconid, across labial moiety of trigonid basin to unite at antero-labial margin with relatively low anterior cingulum; very weak accessory ridge descends anteriorly from metaconid towards trigonid basin; lingual portion of trigonid basin near horizontal, labial portion reduced and sloping. Slight ridge descends posteriorly from metaconid towards talonid basin. Mid-link from hypoconid low, crossing labial moiety of talonid basin to base of protolophid. Posterior of hypolophid unornamented. Basally with slight posterior cingulum.

De Vis (1895) did not designate a holotype from the sixteen specimens which he originally referred to "*Halmaturus*" *vishnu*. The specimen figured in part by De Vis (1895, pl. 17, figs. 3–4) is the most complete and best preserved specimen of this series and is selected as lectotype. Unfortunately the specimen lacks detailed locality information, but its preservation suggests that it has been derived from the Pleistocene fluviatile deposits of the eastern Darling Downs.

Stirton (1957, p. 124) attributed a series of measurements to the type of "*Halmaturus*" *vishnu*. These refer to the lectotype.

MACROPUS FAUNUS De Vis

(Plate 18, figures 1–3)

Macropus faunus De Vis, 1895, Proc. Linn. Soc. N.S.W., 10 (n.s.), pp. 127–129.

Holotype.—F.2924, partial right maxilla with P^3–M^3, juvenile, Darling Downs, S.E.Q. (figd. in part, De Vis, 1895, pl. 18, figs. 4–5).

Measurements of Holotype.—P^3, 11·6 x 5·9; M^1, 13·4 x 10·7; M^2, 16·0 x 12·4; M^3, 17·1 x 13·2.

Description of Holotype.—P^3 moderately elongate, subtriangular in basal outline, broader posteriorly. High longitudinal crest markedly trifid, being cleft by two, deep, vertical sets of grooves. Moderately high hypocone near metacone, connected by strong ridge; posterior ridge from hypocone curving postero-labially above base of crown to unite with slight posterior extension of longitudinal crest from metacone.

$M^1 < M^2 < M^3$; molars subrectangular, slightly constricted across median valley; lophs relatively high, anteriorly bowed; metaloph broader than protoloph in M^1, approximately equal in M^2 and somewhat narrower in M^3. Anterior cingulum relatively high, broad, and moderately short; well-defined, strong fore-link passes posteriorly from near mid-point of anterior cingulum to point linguad to centre of protoloph. Mid-link high, strong, descending labially from protocone, then posteriorly across median valley to unite with short ridge from mid-point of metaloph; median valley V-shaped, delimited lingually by low accessory link in M^3; slight antero-lingual ridge from metacone descends into median valley. Strong postero-labial ridge descends from hypocone to near postero-labial margin of crown, uniting with extremely slight, posterior ridge from metacone, with production of posterior fossette; posterior surface of ridge from hypocone with two vertical grooves.

The specimen designated by De Vis (1895) as the holotype of *Macropus faunus* lacks detailed locality information, but its preservation indicates that it was most probably derived from the Pleistocene fluviatile deposits of the eastern Darling Downs. Since De Vis possessed only one maxillary specimen of *M. faunus*, the holotype, the figured permanent upper premolar and M^3 (De Vis, 1895, pl. 18, figs. 4–5) must relate to this specimen, although M^3 has been poorly illustrated.

MACROPUS MAGISTER De Vis

(Plate 19, figures 1–3)

Macropus magister De Vis, 1895, Proc. Linn. Soc. N.S.W., 10 (n.s.), pp. 120–124.

LECTOTYPE.—F.645, partial cranium containing P^2–M^2, P^3 exposed by fenestration, juvenile, Ravensthorpe, Pilton, S.E.Q., from Pleistocene fluviatile deposits (figd. in part, De Vis, 1895, pl. 18, figs. 13, 14).

MEASUREMENTS OF LECTOTYPE.—P^2, 9·3 x 6·7; DP^3, 11·0 x 8·8; P^3, 10·4 x 5·9; M^1, 13·5 x 9·8; M^2, 14·0 x 10·5.

DESCRIPTION OF LECTOTYPE.—Maxilla laterally with infraorbital foramen opening above anterior margin of P^2; antercrbital canal short; inferior process of anterior zygoma root moderately strong; palate entire, with palatine well developed, extending anteriorly to posterior root of M^1; jugal laterally excavated; zygomatic arch markedly sinuous, converging anteriorly, squamosal in narrow anterior contact with frontal, subsquamosal foramen antero-dorsal to external auditory meatus, with prominent foramen within meatus opening anteriorly into sinus of root of zygoma; postglenoid process of squamosal moderately well developed. Tympanic deep, complete dorsally, poorly united with squamosal in roof of meatus. Alisphenoid not inflated, in slight contact with basioccipital, with foramen ovale bounded antero-laterally by deep groove. Paraoccipital process elongate.

P^2 somewhat reduced, subrectangular in basal outline, broader posteriorly; crown with high, bifid longitudinal crest, being divided mesially by a deep, vertical labial groove. Tooth much worn lingually. Small basal style present, labiad to metacone.

DP^3 molariform, not constricted across median valley; lophs moderately low, anteriorly bowed, with metaloph broader than protoloph. Anterior cingulum relatively high and broad, moderately short; well-defined strong fore-link passes postero-lingually from near mid-point of anterior cingulum to protoloph; slight ridge descends anteriorly from paracone; small fossette formed antero-lingually. Very slight ridge descends postero-lingually from paracone into median valley, accompanied by broad, very low ridge from surface of protoloph; strong, moderately high mid-link descends across median valley to near mid-point of metaloph; low ridge paralleling loph in lingual moiety of median valley. Low ridge descends lingually from hypoconid to base of crown and stronger ridge descends postero-labially.

P^3 moderately short, robust, subtriangular in basal outline, broader posteriorly; crown with high bifid longitudinal crest, being cleft at approximately one third distance along crest from paracone; posterior portion subdivided by extremely weak vertical set of grooves. Hypocone almost as high as metacone, with slight anterior ridge to tooth base, slight postero-labial ridge to unite with extension of longitudinal crest above tooth base, and labial ridge to below metacone. Slight indication of basal style present, labiad to metacone.

$M^1 < M^2$; molars subrectangular in basal outline, only extremely slightly constricted across median valley; lophs moderately low, anteriorly bowed, with metaloph broader than protoloph in M^1. Anterior cingulum relatively high and broad, moderately short; well-defined, strong fore-link passes postero-lingually from near mid-point of anterior cingulum to protoloph; accessory link present in labial moiety of anterior cingulum of M^1. Moderate ridge descends anteriorly from paracone but posterior ridge reduced; slight antero-lingual fossette in M^2. Base of protoloph broadly swollen labially near mid-link. Mid-link strong, moderately high, descending postero-labially from protoloph then posteriorly to unite with ridge from near mid-point of metaloph above median valley; mid-link ornamented labially by accessory ridge to protoloph. Slight ridges descend anteriorly and posteriorly from metacone; strong ridge descends postero-labially from hypocone to postero-labial margin of crown with production of posterior fossette.

De Vis (1895) did not designate a holotype for *Macropus magister*, but mentioned in his discussion relating to *M. pan*, that the type was maxillary, The lectotype, selected from the large series of specimens originally referred to *M. magister*, contains the most complete, and best preserved juvenile maxillary dentition. While De Vis' figures are poor it is considered likely that P^2 and P^3 of this specimen were illustrated by him (1895, pl. 18, figs. 13–14), and the dimensions given for the permanent premolar support this.

MACROPUS PAN De Vis

(Plate 18, figures 4–6)

Macropus pan De Vis, 1895, Proc. Linn. Soc. N.S.W., 10 (n.s.), pp. 124–127.

HOLOTYPE.—F.2925, partial right maxilla with DP^3–M^2, juvenile, Darling Downs, S.E.Q.

MEASUREMENTS OF HOLOTYPE.—DP^3, 10·6 x 8·1; P^3, ——; M^1, 13·7 x —; M^2, 16·3 x 12·6.

DESCRIPTION OF HOLOTYPE.—DP^3 molariform, but too worn to be adequately described. Semblance of accessory link present in labial moiety of median valley.

$M^1 < M^2$; molars subovate in basal outline, not constricted across median valley; lophs high, anteriorly bowed; protoloph broader than metaloph in M^2. Anterior cingulum relatively high, narrow, moderately short; poorly defined, weak fore-link passes anteriorly from point linguad to mid-point of protoloph to anterior cingulum; lingual moiety of anterior cingulum descending markedly; slight ridges descend anteriorly and posteriorly from paracone. Mid-link high, strong, descending postero-labially then posteriorly from protocone, to unite with ridge from near mid-point of metaloph above median valley; valley sharply V-shaped; anterior ridge from metacone weak, descending into median valley to accessory link across labial moiety of valley; accessory link unites with weak posterior ridge from paracone; posterior surface of protoloph between paracone ridge and mid-link broadly swollen. Well defined ridge descends postero-labially from hypocone to unite with weak ridge from metacone above base of crown, labiad to mid-line, with productior of posterior fossette. Posterior surface of coarse hypocone ridge moderately deeply grooved in M^2.

De Vis (1895) designated a juvenile maxilla as the holotype of *Macropus pan*. He did not figure this specimen, but only one such juvenile maxilla is included in the originally referred material, this containing DP^3–M^2 and measuring 40·0.

Detailed locality information is lacking for the holotype, but its preservation indicates that it has most likely been derived from the Chinchilla Sand.

SUMMARY

The holotypes of De Vis' (1895) macropodid species, "*Halmaturus*" *indra*, "*H.*" *siva*, *Macropus faunus*, and *M. pan*, together with the lectotypes selected for "*H.*" *dryas*, "*H.*" *thor*, "*H.*" *vinceus*, "*H.*" *vishnu*, and *M. magister* are described and figured.

It is concluded that "*H.*" *odin* De Vis represents a *nomen dubium*.

LITERATURE CITED

Bartholomai, A., 1962. A New Species of *Thylacoleo* and Notes on Some Caudal Vertebrae of *Palorchestes azael*. *Mem. Qd Mus.*, 14, pp. 33–40.

————————, 1963. Revision of the Extinct Macropodid Genus *Sthenurus* Owen in Queensland. *Mem. Qd Mus.*, 14, pp. 51–76.

Stirton, R. A., 1957. Tertiary Marsupials from Victoria, Australia. *Mem. Nat. Mus. Vic.*, 21, pp. 121–134.

De Vis, C. W., 1895. A Review of the Fossil Jaws of the Macropodidae in the Queensland Museum. *Proc. Linn. Soc. N.S.W.*, 10 (n.s.), pp. 75–133.

Woods, J. T., 1958. The Extinct Marsupial Genus *Palorchestes* Owen. *Mem. Qd Mus.*, 13, pp. 177–193.

EXPLANATION OF PLATES

Plate XV

" *Halmaturus* " *dryas* De Vis, F.3582, lectotype.

Figs. 1, 2. Stereopair of occlusal view.

Fig. 3. Labial view.

" *Halmaturus* " *indra* De Vis, F.3595, holotype.

Figs. 4, 5. Stereopair of occlusal view.

Fig. 3. Labial view.

Plate XVI

" *Halmaturus* " *vishnu* De Vis, F.3860, lectotype.

Figs. 1, 2. Stereopair of occlusal view.

Fig. 3. Labial view.

" *Halmaturus* " *siva* De Vis, F.2926, holotype.

Figs. 4, 5. Stereopair of occlusal view.

Fig. 6. Labial view.

Plate XVII

" *Halmaturus* " *thor* De Vis, F.3602, lectotype.

Figs. 1, 2. Stereopair of occlusal view.

Fig. 3. Labial view.

" *Halmaturus* " *vinceus* De Vis, F.3577, lectotype.

Fig. 4. Labial view.

Figs. 5, 6. Stereopair of occlusal view.

Plate XVIII

Macropus faunus De Vis, F.2924, holotype.

Figs. 1, 2. Stereopair of occlusal view.

Fig. 3. Labial view.

Macropus pan De Vis, F.2925, holotype.

Fig. 4. Labial view.

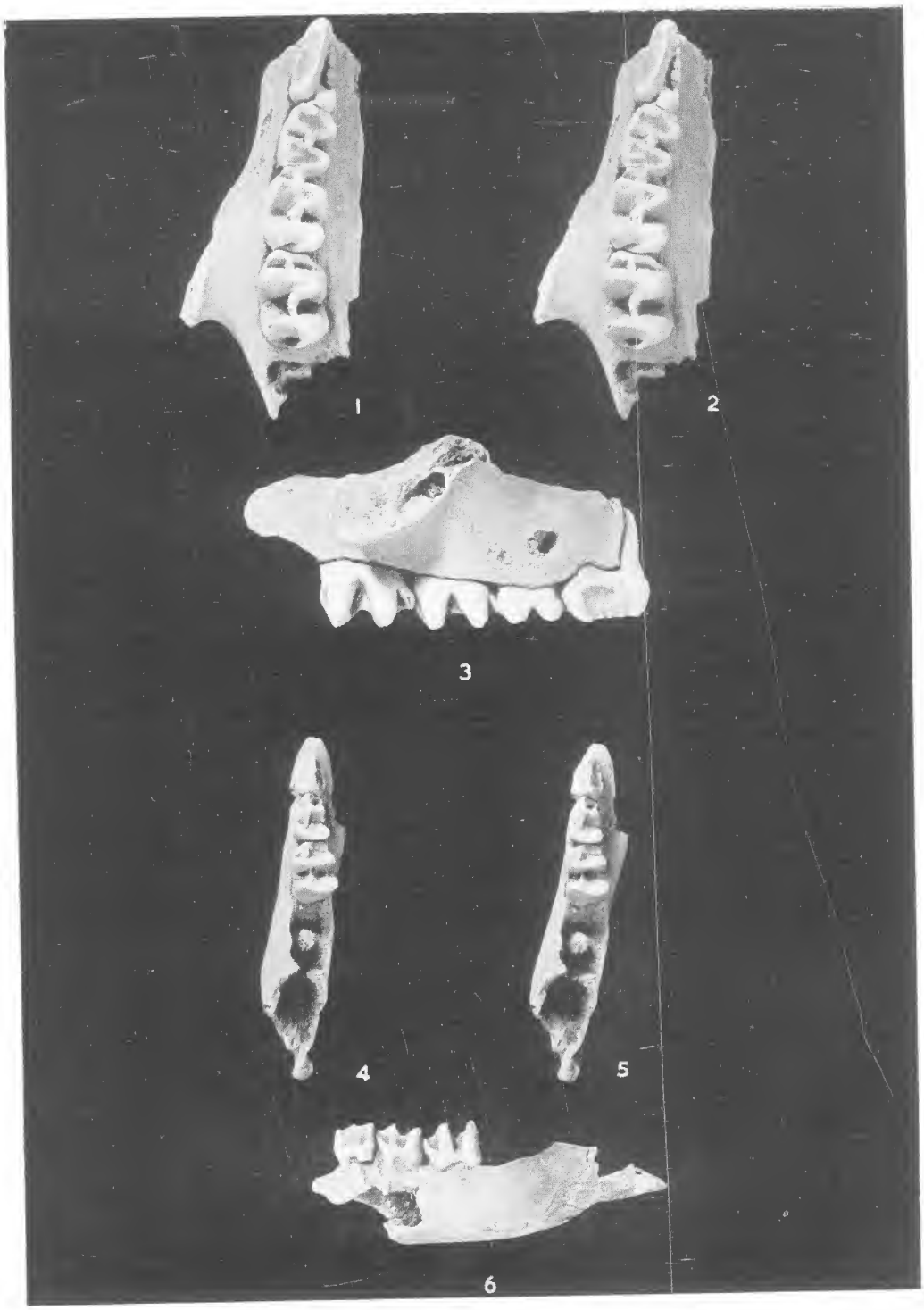
Figs. 5, 6. Stereopair of occlusal view.

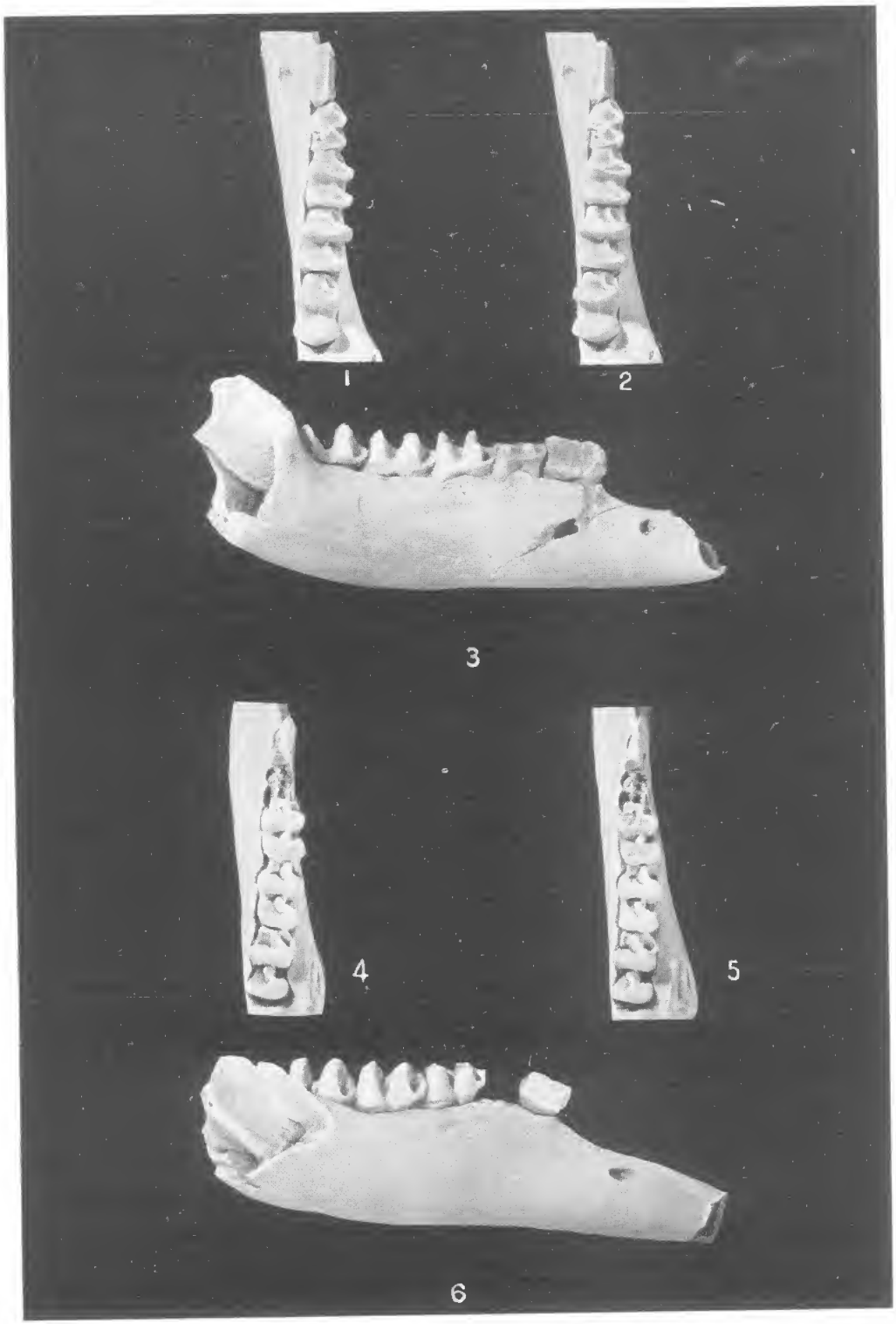
Plate XIX

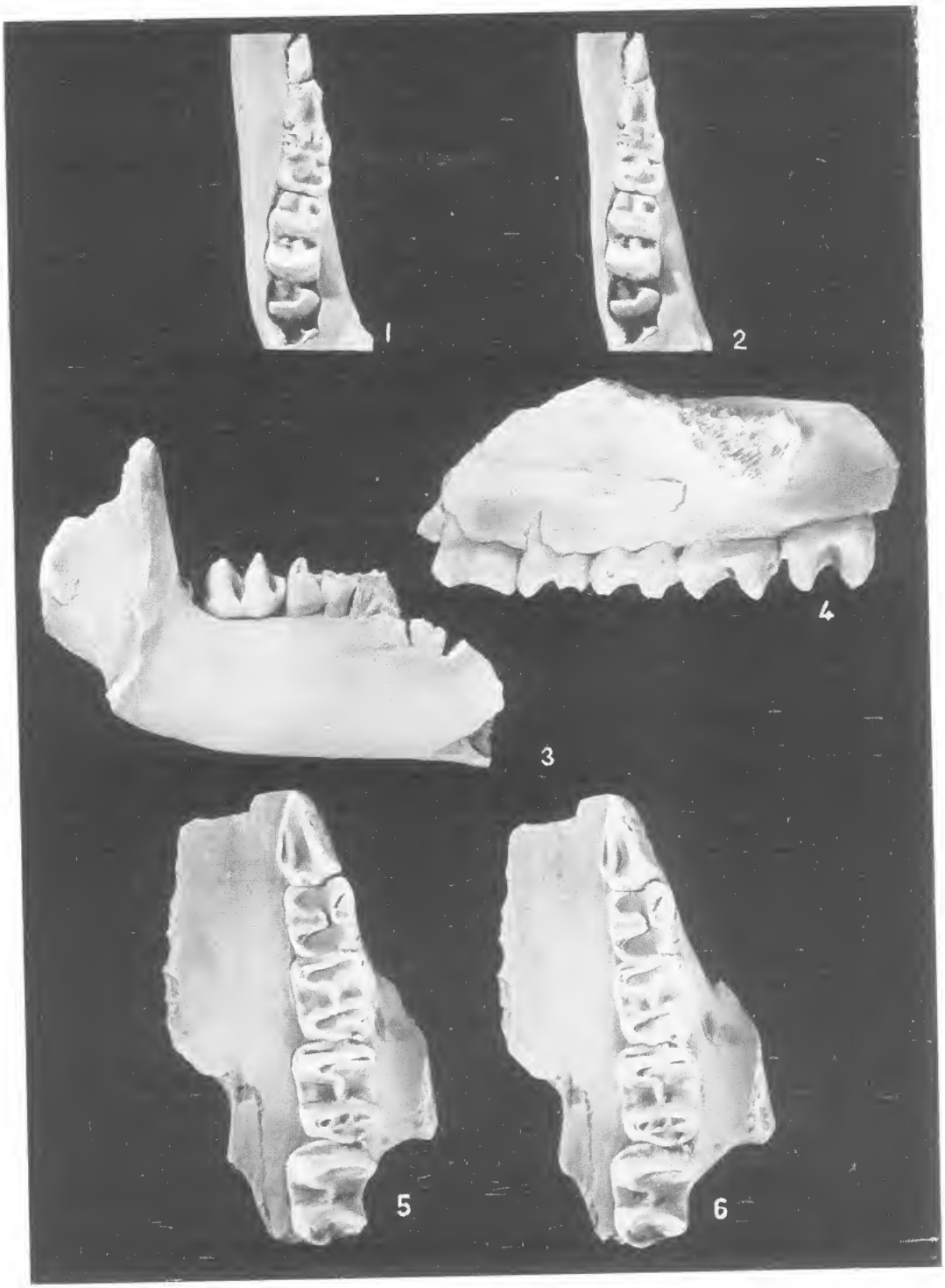
Macropus magister De Vis, F.645, lectotype.

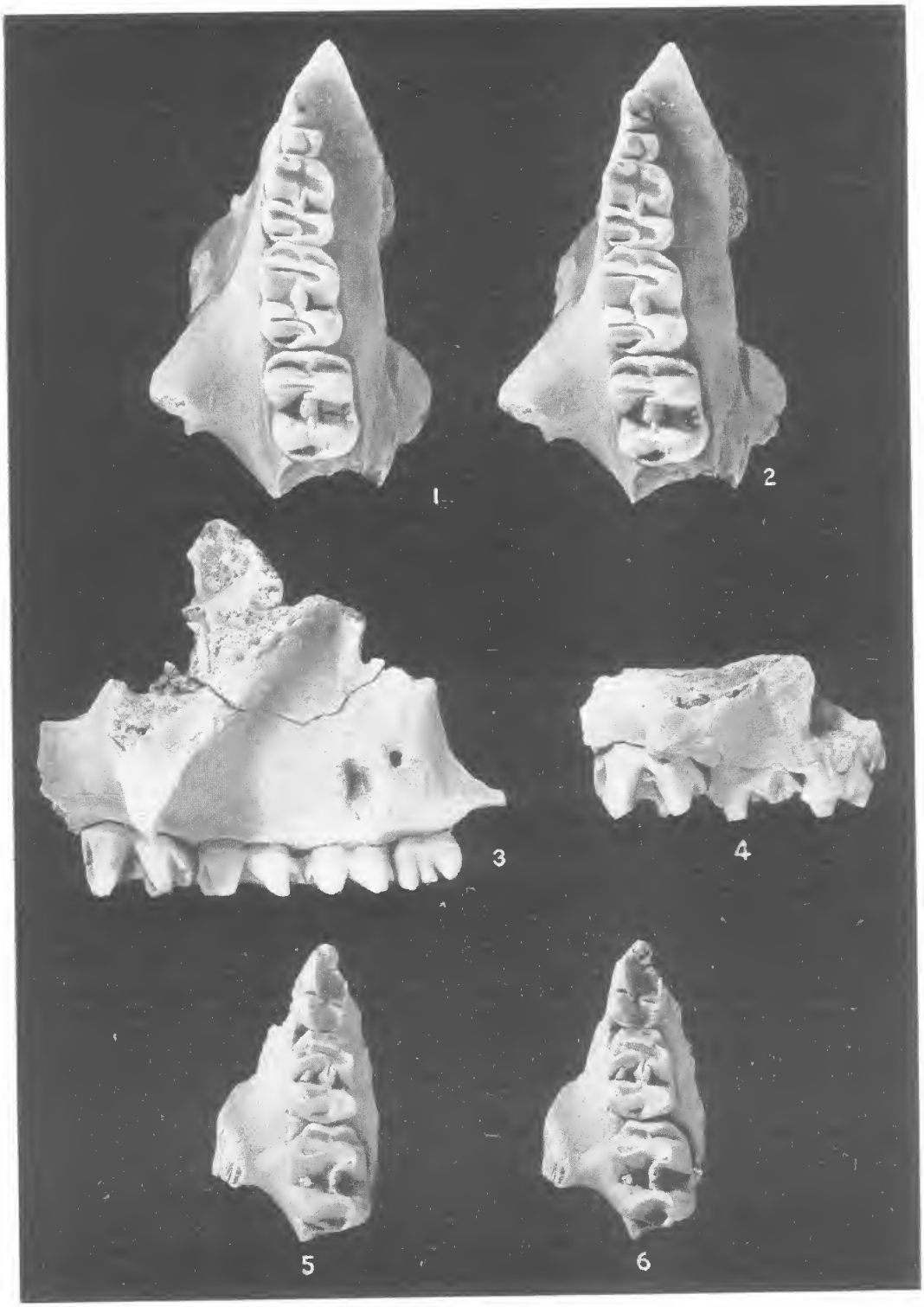
Figs. 1, 2. Stereopair of occlusal view.

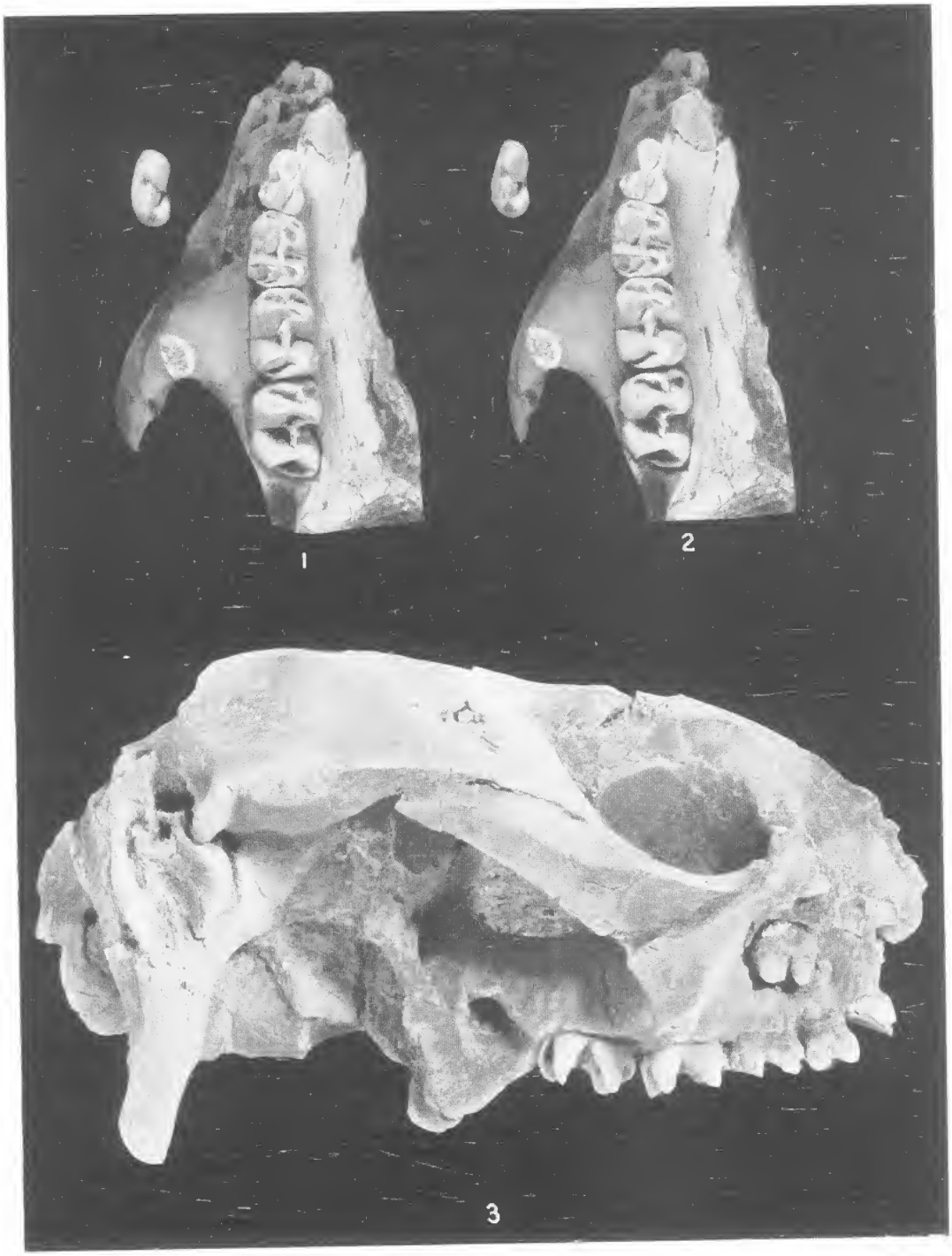
Fig. 3. Labial view.


1
2
3
4
5
6


1
2
3
4
5
6


1
2
3
4
5
6


1
2
3
4
5
6


1
2
3

THE AUSTRALIAN SESARMINAE (CRUSTACEA : BRACHYURA) : GENERA *HELICE*, *HELOGRAPSUS* NOV., *CYCLOGRAPSUS*, AND *PARAGRAPSUS*

B. M. Campbell, Queensland Museum

and

D. J. G. Griffin, University of Tasmania

ABSTRACT

Ten species of sesarmine crab, seven occurring within Australia, are described and figured. Genera are diagnosed and a key to the Indo–West Pacific species of the genus *Cyclograpsus* H. Milne Edwards is provided. A new genus, *Helograpsus*, is set up to contain *Chasmagnathus haswellianus* Whitelegge, formerly referred to *Helice* de Haan. *Cyclograpsus punctatus* H. Milne Edwards is not considered to have a circum-subantarctic distribution, but to be confined to South Africa and Chile; *C. granulosus* H. Milne Edwards is regarded as a species distinct from *C. audouinii* H. Milne Edwards, and confined to south-eastern Australia; *C. whitei* H. Milne Edwards is shown to be conspecific with the New Zealand *C. lavauxi* H. Milne Edwards; and a new species, *C. insularum* is described from Lord Howe Island, Norfolk Island, Kermadec Island and New Zealand.

Independent interest in the ecology of the Australian grapsids on the part of both authors led to the realisation of a need for prior clarification of several taxonomic points. Rather than publish separate small papers on the species of immediate interest it was decided that a comprehensive treatment of the subfamily Sesarminae was required before any experimental work could be attempted.

Members of this subfamily can be readily identified by the presence of an oblique hairy ridge running diagonally across the third maxillipeds. This feature is usually accompanied by a series of short hairs and granules regularly arranged in rows on the pterygostome, the whole mechanism presumably functioning as a reoxygenation device for water held in the gill chamber (Verwey, 1930). The genera to be considered in this first paper (*Helice* de Haan, 1833; *Helograpsus* nov.; *Cyclograpsus* H. Milne Edwards, 1837; *Paragrapsus* H. Milne Edwards, 1853) are characterised by having the reticulation of the pterygostome less fully developed than in other genera of the subfamily, reaching a maximum in *Helice*.

The following key can be used to distinguish these genera.

1. Eyestalks as long as frontal width; two distinct teeth behind external orbital angles; carapace broad..... *Metaplax* H. Milne Edwards (not from Australia)

   Eyestalks much shorter than frontal width..... 2

2 (1). Frontal width markedly less than half fronto-orbital width; frontal margin curving imperceptibly into very oblique inner margins of orbits; epistome visible beyond front in dorsal view; third segment of male abdomen much broader than any other segment..... 3

   Frontal width half or slightly more than half fronto-orbital width; frontal margin forming a distinct angle with inner margins of orbits; epistome not visible in dorsal view; third segment of male abdomen little broader than others..... 4

3 (2). Lateral margins of carapace very convex in their entire course..... ..... *Chasmagnathus* de Haan (not from Australia)

   Lateral margins of carapace subparallel in their posterior half..... ..... *Helice* de Haan

4 (2). Carapace deep (depth *c.* 0·65 length), vaulted, with distinct anterolateral notch; legs slender; terminal segment of female abdomen 1·5 times as broad as long..... *Helograpsus* nov.

   Carapace flattened (depth less than 0·6 times length); legs sturdy; terminal segment of female abdomen twice as broad as long..... 5

5 (4). Anterolateral margins of carapace entire or obscurely notched; post frontal lobes indistinct, front curving smoothly downwards..... ..... *Cyclograpsus* H. Milne Edwards

   Anterolateral margins of carapace distinctly toothed; post frontal lobes distinct; front projecting, rather shelf-like..... ..... *Paragrapsus* H. Milne Edwards

The terminology used follows that of Rathbun (1918, pp. 6–8, figs. 1, 2). Where species have been adequately dealt with in recent literature, synonymies have been abbreviated and references with more complete synonymies indicated. All line drawings have been prepared by camera lucida or by meticulous measurement of proportions.

The collections of the South Australian Museum, Australian Museum, Tasmanian Museum, National Museum of Victoria, Queensland Museum, and Western Australian Museum have been supplemented by considerable personal collecting on the Queensland and Tasmanian coasts. This additional material has been deposited at the Queensland Museum and the Tasmanian Museum respectively.

Genus **HELICE** de Haan

Helice de Haan, 1833, p. 28. (Type species: *Ocypoda* (*Helice*) *tridens* de Haan, 1835, by monotypy). (*fide* Official List of Generic Names in Zoology, 1958, Name No. 315.)

Diagnosis

Carapace.—Regions moderately well defined. Anterolateral margins distinctly notched. Posterolateral margins subparallel, lateral borders not smoothly convex.

Front.—Smoothly deflexed. Frontal width markedly less than half fronto-orbital width. Frontal border and oblique inner margins of orbits merging smoothly, with no distinct angle between them.

Epistome usually visible beyond front in dorsal view.

Pterygostome.—With granules and setae often in orderly lines, but not as conspicuously reticulate as in *Sesarma*.

Antenna 2.—Not excluded from orbital hiatus.

Abdomen.—Seven segmented. In male not occupying whole breadth of sternum between last legs. Third segment expanded laterally, much broader than first and second segments. Ultimate segment of female not deeply impacted in penultimate segment.

Distribution

Throughout the Indo–West Pacific region from Japan to Australia, from Tahiti to Dar es Salaam.

Discussion

Tesch (1918) listed ten species of this genus. Of these, *H. gaimardii* (H. Milne Edwards) must be transferred to *Paragrapsus* (from whence Tesch removed it), *H. lucasi* H. Milne Edwards has been synonymised with *H. crassa* Dana (*fide* Bennett, 1964), and *Chasmagnathus subquadratus* Dana and *Paragrapsus urvillei* H. Milne Edwards are too poorly known to be included with certainty in this genus. A possible addition to the list is *H. pilimana* A. Milne Edwards, which may prove not to be synonymous with *H. leachii* Hess.

Of the seven species remaining two have been recorded from Australia. *H. crassa* was described by Dana from Illawarra, New South Wales, but in view of the confusion existing in relation to Dana's localities and the subsequent collecting of this species from New Zealand this record is open to doubt. The only further record of *H. crassa* from the Australian coast is based on a small male from Port Jackson (Miers, 1886). No description was given and as the recorded habitat (6 fms) is unusual for *Helice* this identification may have been erroneous.

HELICE LEACHII Hess

(Text-figs. 1A, 2A ; pl. 20, fig. 1 ; pl. 23, fig. 1)

Helice leachii Hess, 1865, p. 153. Haswell, 1882b, p. 107. de Man, 1887, p. 702. Ortmann, 1894b, p. 57 (*fide* Tesch 1918). Rathbun, 1907, p. 36. Tesch, 1918, p. 120. Parisi, 1918, p. 108, pl. 8, fig. 2. McNeill, 1920, p. 109. Sakai, 1939, pp. 696–7, fig. 126. Crosnier, 1965, pp. 76–8, figs. 125–8, pl. 5, fig. 2.

(?) *Helice pilimana* A. Milne Edwards, 1873, p. 313, pl. 18, fig. 1.

Helice subquadrata (Dana). Tesch, 1918, pp. 120–4, pl. 6, fig. 1.

(non) *Chasmagnathus subquadratus* Dana, 1852a, p. 251 ; 1852b, p. 363, pl. 23, fig. 5. Hess, 1865, p. 152. Haswell, 1882b, p. 106.

Material Examined

15 males (9–24 mm) ; 21 females (13–24 mm).

Queensland : Johnstone R., Townsville, Yeppoon, Boyne R., Burnett R., Mary R., Noosa, Wynnum, Redland Bay, Currumbin Ck. New South Wales : Trial Bay, Middle Harbour.

Material Illustrated

Male, 24 mm, Burnett R., Dec. 1961, B.C., Qd Mus. W.2272/1.

Male, 25 mm, Curtis I., Gladstone, 22.iv.62, B.C., Qd Mus. W.2275/1. (*a* in text-fig. 1A).

Male, 18·5 mm. Middle Harbour, Sydney, Jan. 1959, B.C., Qd Mus. W.2269. (*b* in text-fig. 1A).

Description

Carapace.—Quadrate, broader than long (c. 1.2 times), markedly vaulted longitudinally, more flattened transversely. Surface granular, punctate posteriorly, with short hairs evenly distributed among the granules except on mesogastric, cardiac, and intestinal regions which are naked.

Mesogastric region well defined, projecting anteriorly into deep frontal furrow to level of orbits ; on either side of frontal furrow adjacent to termination of mesogastric region there are 1 or 2 longer bristles. Protogastric regions usually obvious (less so in female). Epigastric lobes barely discernable. Cardiac region well defined.

Anterior posterolateral ridge oblique. Posterior posterolateral ridge strong, transverse, running parallel to margin of carapace above last two legs, from lateral margins of intestinal region to end short of carapace margin.

Lateral borders sinuous, with two forwardly directed anterolateral teeth, the second much the smaller.

Orbits wide, posterior margin sinuous, slightly oblique, continuous with very oblique inner margins, a slight discontinuity discernable between inner margins of orbit and front.

Front narrow, rounded, slightly sinuous on either side of median notch in frontal view. Frontal area smoothly deflexed so that plane of median frontal area is almost continuous with that of epistome. Epistome visible beyond front in dorsal view.

Sub-orbital crest of male variable, usually resolvable into a series of *c.* 8 distinct granules medially, followed by a ridge composed of *c.* 6 granules, the first microscopic, the remainder increasing progressively, the last two or three striate; then follows a very large, striate, asymmetrical granule (lying below the cornea), a very low rounded striate granule and two striate granules of similar shape to the largest, but decreasing in size, the last sometimes microscopic, level with the first antero-lateral notch.

In the female the crest bears a uniform series of low granules.

Chelipeds.—Merus with upper border very faintly granulate, lower border granulate, anterior border with a row of sparsely distributed larger granules. Distal end of anterior border in male bearing a horny stridulating ridge on its inner face.

Carpus with inner angle variable, sometimes with a smooth or serrate series of granules progressively increasing in size to a small spine; sometimes with one or two small spinules only. A variable number of small spines or granules may be present on inner face of carpus just below inner angle.

Chela in large males almost as high as long, but relatively longer in smaller specimens and females. Outer surface punctate, especially anteriorly; low granular carina on lower third running distally from near wrist articulation; granulate dorsally, and curving inwards to form an overhanging ledge above inner face. Inner face with some coarse granules, concave at base of immovable finger; ventral border with short, prominent, granular ridge at wrist articulation. A variable amount of felting may be present on outer surface of chela near wrist articulation, and between bases of fingers. (This variation is shown in Text-fig. 1A). Fingers punctate, with low dentition and wide gape in larger males, less in females and small males.

Ambulatory Legs.—Long and slender. Second leg *c.* 1·7 times carapace breadth. Merus finely granulate on anterior edge. Carpus and propodus of first leg with dense felting on upper border and upper two-thirds of anterior surfaces and on distal half of lower border. Dactyl conical, long and slender, with 6 longitudinal grooves carrying felting which is densest dorsally, reduced ventrally.

Last leg with thin row of felting, expanded distally, on upper border of carpus and propodus, tufts on distal extremity of propodus, a short row on distal third of ventral border of propodus. Dactyl as for first leg but shorter.

Tufts of hair present between bases of first and second, and second and third ambulatory legs.

Sternum.—Very densely hirsute anterior to abdomen.

Male Abdomen.—Fringed with long, dark hairs, longest proximally. Third segment much the broadest. Fourth and fifth segments evenly tapering to sixth, which curves gradually inwards to narrow ultimate segment. Ultimate segment longer than broad (*c.* 1·2 times), with rounded hirsute tip.

Ultimate segment of female abdomen as long as broad, not deeply impacted in penultimate segment.

Colour.—Carapace dark purplish with cream mottling posteriorly. The proportion of purple to cream, and the degree of mottling of the carapace is very variable. Legs purple and cream mottled. Chelae cream, carpus purple above, merus purplish where visible in dorsal view.

Habitat

From inlets and bays, rarely penetrating for any great distance up estuaries (in the Burnett R. to a minimum high water salinity of *c.* 15‰). High up the beach, near or above high water mark, burrowing in a firm substrate which ranges from dirty sand to firm mud or hard packed earth. It is quite usual for these crabs to burrow in very difficult areas, among loose shale, stones, or mangrove roots. The burrows are usually simple but may have long horizontal offshoots running for up to 12 feet, a few inches below the surface of the mud flat (mouth of Burnett R.).

Distribution

From Dar es Salaam (Ortmann, 1894b) to Japan (Rathbun, 1907; Sakai, 1939), Australia, and possibly New Caledonia (A. Milne Edwards, 1873).

Within Australia from Port Jackson and Trial Bay in the south (McNeill, 1920) to Johnstone R. in the north.

Discussion

Tesch (1918) referred a single male specimen from Lombok to *H. subquadrata* (Dana). His detailed description falls entirely within the variability shown to exist in the present species by a series of specimens from localities extending over 1400 miles of the east Australian coast. Although some apparent discrepancies exist between the present description and that given by Tesch, these can be reconciled as follows:

1. Epistome projecting beyond front in dorsal view. This obviously depends on the interpretation of "dorsal". If the crab is allowed to sit on a horizontal surface the epistome is readily visible from above. If the crab is held with the carapace horizontal the epistome is not visible.

2. Suborbital ridge. Of the two tubercles present behind the large one, the last is often minute, hidden among the hairs of the pterygostome.

3. The carina on the chela of *H. leachii* is not prominent, but quite as Tesch described for his specimen.

4. The patch of hairs at the base of the fingers of the chela may be quite minute in *H. leachii*, and is probably never as large as that figured by A. Milne Edwards for *H. pilimana*.

5. The rectangular ornamentation of the ambulatory meri, which Tesch denies in *H. leachii*, is actually present, and quite as he describes for "*H. subquadrata*".

The status of Dana's *Chasmagnathus subquadratus* must still remain uncertain. Attempts to locate the type have been unsuccessful. Garth (1958, p. 4) has commented on the destruction of the types of several workers' species, including those of Dana, and it seems probable that the specimen is no longer in existence. Although Dana's description has been requoted several times in the literature no further records of this

species can unequivocably be accepted (the record of Ortmann (1894a) from Tahiti was not accompanied by a description). The type locality is recorded as " New South Wales ? New Zealand ? ", but Chilton and Bennett (1929), and Bennett (1964) have denied the presence of this species in New Zealand. This would suggest that the original specimen was collected in New South Wales, but even in the light of present knowledge of the distribution of sesarmine crabs on the east Australian coast it is not possible to assign any known species from this region to *Chasmagnathus subquadratus*. Dana stated that the front and anterolateral margins of his specimen were as in *C. laevis* (= *Paragrapsus laevis*). If this was so the specimen could not be conspecific with *H. leachii*, and it would now be placed in the genus *Paragrapsus*. Kingsley (1880, p. 220) suggested that Dana's *C. subquadratus* might be synonymous with his *C. laevis*, and Dana himself (1852b, p 364) doubtfully placed *Cyclograpsus gaimardii* H. Milne Edwards (= *Paragrapsus gaimardii*) in the synonymy of *C. subquadratus*. The shape of the male abdomen (Dana, 1852b, pl. 23, fig. 5C) and the hirsute first sternite, however, exclude the possibility of synonymising this with any known species of *Paragrapsus*.

It has become customary to place the New Caledonian *H. pilimana* A. Milne Edwards in the synonymy of *H. leachii*, but this practice is open to question. Although de Man (1887) compared Hess's type (of *H. leachii*) with Milne Edwards' description and figures, and pronounced them certainly identical, this certainty was apparently tempered with some doubt, for later (*loc. cit.*, p. 702) he says " Wenn die *Helice leachii* mit der *pilimana* wirklich identisch ist, muss der latstere Name ans der Wissenschaft verschwinden." When the present series of specimens is used for comparison, this doubt must be increased. Not even in the southern specimen does the tuft of hairs at the base of the immovable finger approach the size of that figured by Milne Edwards (1873, pl. 18, fig. 1a), and the carina on the outer surface of the chela is never as distinct. There is, however, almost invariably a conspicuous tuft on the outer surface of the chela near the wrist articulation which is not shown by Milne Edwards. In *H. pilimana* the ischium of the third maxilliped is shown (Milne Edwards, 1873, pl. 18, fig. 1c) to be naked except for the oblique hairy ridge and a fringe of setae on the inner edge. In *H. leachii* the ischium is almost covered with longish hairs. The articulation of the palp of the maxilliped is nearer the external angle of the merus than in Milne Edwards' figure.

Photographs of the holotype of *H. pilimana* (a dry specimen in the Muséum National d'Histoire Naturelle, Paris) suggest that the carapace is flatter than in *H. leachii*, more punctate, and with the mesogastric region less defined. The first epibranchial teeth behind the external orbital angles appear more laterally flaring than in *H. leachii*, the lateral margins of the carapace less sinuous. Because the mode of preservation permits photos of only the dorsal view, and additional specimens from New Caledonia are not available, some slight doubt remains as to the true status of *H. pilimana*.

Genus **HELOGRAPSUS** nov.

Type species: *Chasmagnathus haswellianus* Whitelegge, 1889.

The generic name has been formed by a combination of "*Helice*" and "*Cyclograpsus*", to both of which the present genus bears superficial resemblance.

Diagnosis

Carapace.—Vaulted longitudinally, and quite deep (0·65 times length). Smooth, with regions distinguishable but only cardiac and intestinal well defined.

Post-frontal lobes inconspicuous.

Front.—Smoothly deflexed. Frontal width slightly more than half fronto-orbital width. Lateral margins of front not passing imperceptibly into very oblique inner borders of orbits.

Anterolateral Borders.—With a distinct notch behind the external orbital angle, but with no distinctly projecting tooth.

Pterygostome.—With granules and setae not in orderly arrangement.

Epistome.—Not projecting beyond front in dorsal view.

Antenna 2.—Not excluded from orbital hiatus.

Chelipeds.—Subequal, with palm and wrist swollen in adult males.

Ambulatory Legs.—Slender, merus of second pair four times as long as broad.

Abdomen.—Seven segmented. In males, not occupying the whole breadth of sternum between the last legs; third segment not very greatly expanded laterally. Ultimate segment in mature female broader than long (*c.* 1·5 times), only slightly impacted in penultimate segment.

Discussion

The species for which this monotypic genus has been erected was first placed by Haswell (1882a) in the genus *Chasmagnathus*. It has since been transferred to *Helice*, but cannot remain in that genus because it possesses the following characters.

1. The inner margin of the orbit is not oblique as in *Helice*, and forms a distinct angle with the front of the carapace.

2. The front is broad.

3. The male abdomen tapers regularly, the third segment is little broader than the others.

4. The epistome does not project beyond the front in dorsal view.

5. The abdomen of the female is subcircular, the ultimate segment broader in relation to its length.

All of these characters are held in common with *Cyclograpsus* and *Paragrapsus* and the species undoubtedly has close affinities with these genera. It is excluded from them on the following counts.

1. The carapace is too deep (length 1·5 to 1·6 times depth as against 1·75 to 1·9 times in *Paragrapsus*, 1·85 to 2 times in *Cyclograpsus*), and the longitudinal vaulting is much more pronounced than in *Cyclograpsus*.

2. The ultimate segment of the abdomen in mature females is not as broad in relation to its length (1·5 times) as in *Cyclograpsus* and *Paragrapsus* (more than twice).

3. The front curves down evenly and does not project forward as a " shelf " as in *Paragrapsus*.

4. The anterolateral notch is more distinct, and deeper (particularly in young specimens) than in any of the " notched " species of *Cyclograpsus*.

5. The ambulatory legs of mature specimens (particularly the meri), are more slender than in *Cyclograpsus* or *Paragrapsus*. (In small specimens the legs are broader, approaching those of *Cyclograpsus* and *Paragrapsus*).

HELOGRAPSUS HASWELLIANUS (Whitelegge)

(Text-figs. 1B, 2B ; pl. 20, fig. 2 ; pl. 23, fig. 2)

Chasmagnathus convexus Haswell, 1882a, p. 550 ; 1882b, pp. 106–7. (preocc.)

(non) *Chasmagnathus convexus* de Haan, 1835, pp. 56–7, pl. 7, fig. 5.

Chasmagnathus haswellianus Whitelegge, 1889, p. 229.

Helice haswellianus (Whitelegge). Hale, 1927a, pp. 177–79, figs. 177–79. Tweedie, 1942, p. 19, fig. 5.

Material Examined

75 males (4–25 mm) ; 60 females (5–18 mm).

Queensland : ?Darnley I., Pioneer R., Burnett R., Brisbane R., Victoria Pt., Sinclair I., Tallebudgera Ck., Currumbin Ck.; New South Wales : Wallis Lake, Tuncurry, Broken B., Northbridge, Middle Hbr., Lane Cove, Paramatta, Port Jackson, Botany B., Shoalhaven, Jervis B., Eden. Victoria : Port Phillip. Tasmania : Don R., Tamar R., Triabunna, Carlton R., Derwent R., Bridgewater, Risdon, Glenorchy, Lindisfarne, Bellerive, Brown's R., Howden, Margate. South Australia : Port Adelaide R.

Material Illustrated

Male, 18 mm, Burnett R., Dec. 1961, B.C., Qd Mus. W.2277.

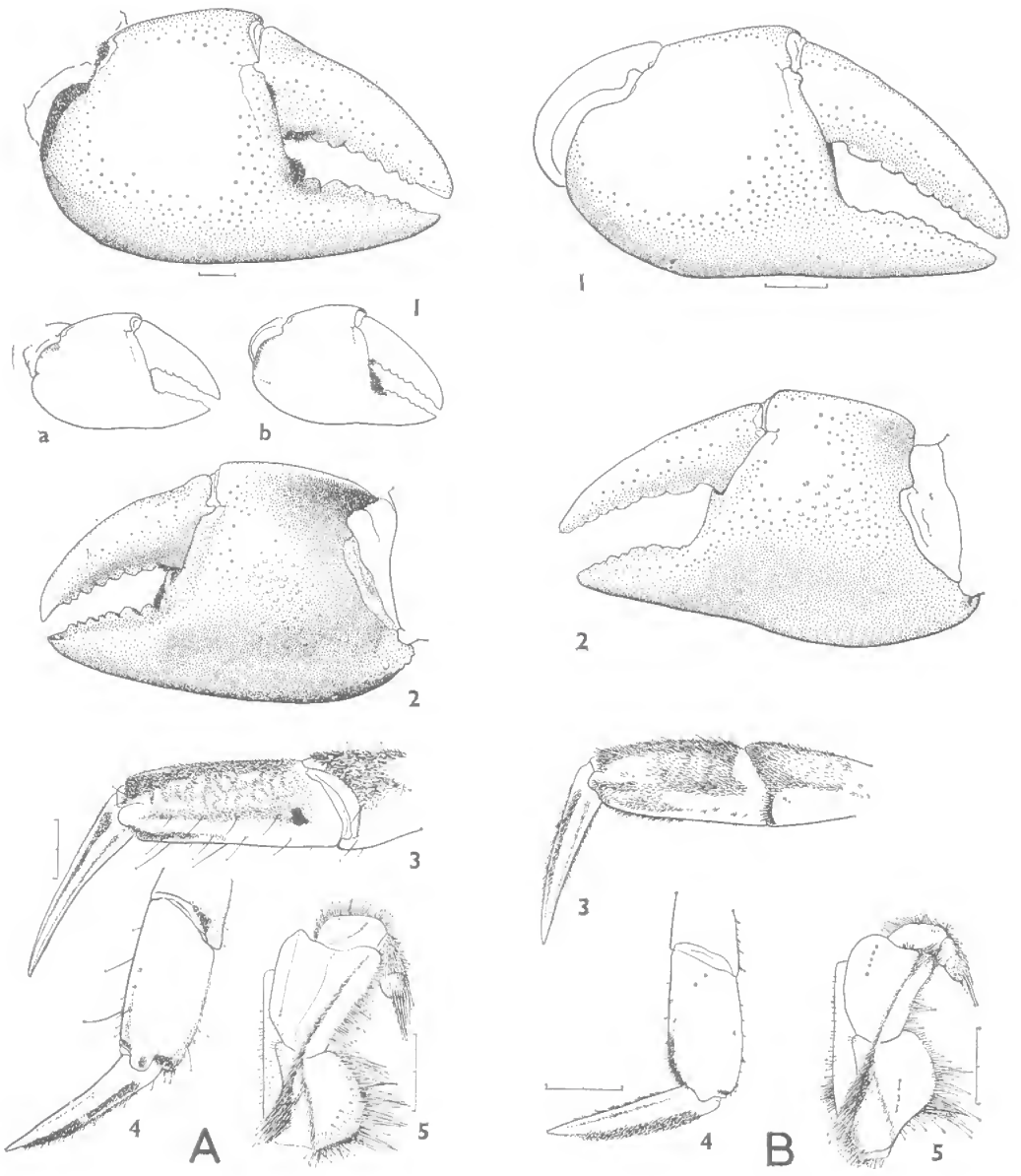
Description

Carapace.—Broader than long (usually 1·2 times, but variable in smaller specimens). Surface microscopically granular, sometimes also punctate. Carapace edge distinctly beaded on lateral margins, indistinctly beaded on frontal margin.

Cardiac and intestinal regions usually distinguishable ; branchial regions swollen ; other regions poorly defined or indistinguishable. Gastro-cardiac groove obvious, median frontal furrow present but shallow. Epigastric lobes indistinct.

Lateral borders convex, broadest just behind the small but distinct anterolateral notches.

Orbits with posterior borders sinuous, slightly oblique.



Text-figure 1.—A, *Helice leachii* ; B, *Helograpsus haswellianus*. 1, Chela, outer face (a, minimum ; b, maximum observed pubescence of gape) ; 2, Chela, inner face ; 3, Right first walking leg, anterior face ; 4, Right last walking leg, posterior face ; 5, Third maxilliped. Scale lines 2 mm.

Front strongly deflexed, thin in ventral view except for a median extension which overlies most of the median epistomal ridge. Epistome extremely hirsute.

Sub-orbital crest in both sexes composed of some 17 to 20 granules regularly decreasing in size laterally so that the last 5 or 6 may be microscopic.

Chelipeds.—Carpus unornamented except for microscopic row of fine granules on upper surface and short row of hairs parallel to this on inner border.

Chela in mature males large, approximately as high as long, externally smooth. Inner surface with raised swelling covered with numerous small granules. Fingers carrying a low dentition and gaping widely proximally.

In females and smaller males, hands are smaller, gape much reduced, and dentition stronger.

Ambulatory Legs.—Long and slender. Second leg *c.* 1·5 times carapace breadth, four times as long as broad, breadth 1·5 times thickness. Merus smooth except for an indistinct low granular ridge on anterior border (more distinct in smaller specimens) and sparsely covered with short, strong bristles.

First and second legs of both sexes with irregular patches or rows of felt on anterior surfaces of carpus and propodus ; dactyli with six longitudinal rows of short hairs.

Third and fourth legs with felting greatly reduced so that only a small patch on distal half of lower edge of propodus and a narrow band on upper edge of both carpus and propodus may be present. Dactyl of last leg long and slender with three upper rows of felt tending to merge and form a broad stripe.

Prominent tufts of hair present between bases of first and second and of second and third ambulatory legs.

Sternum.—Densely hirsute anterior to abdomen, longitudinally vaulted.

Male Abdomen.—Subtriangular. Penultimate segment *c.* 1·5 times as broad as long, twice as broad as ultimate segment. Ultimate segment nearly as broad as long, with subparallel sides and rounded tip.

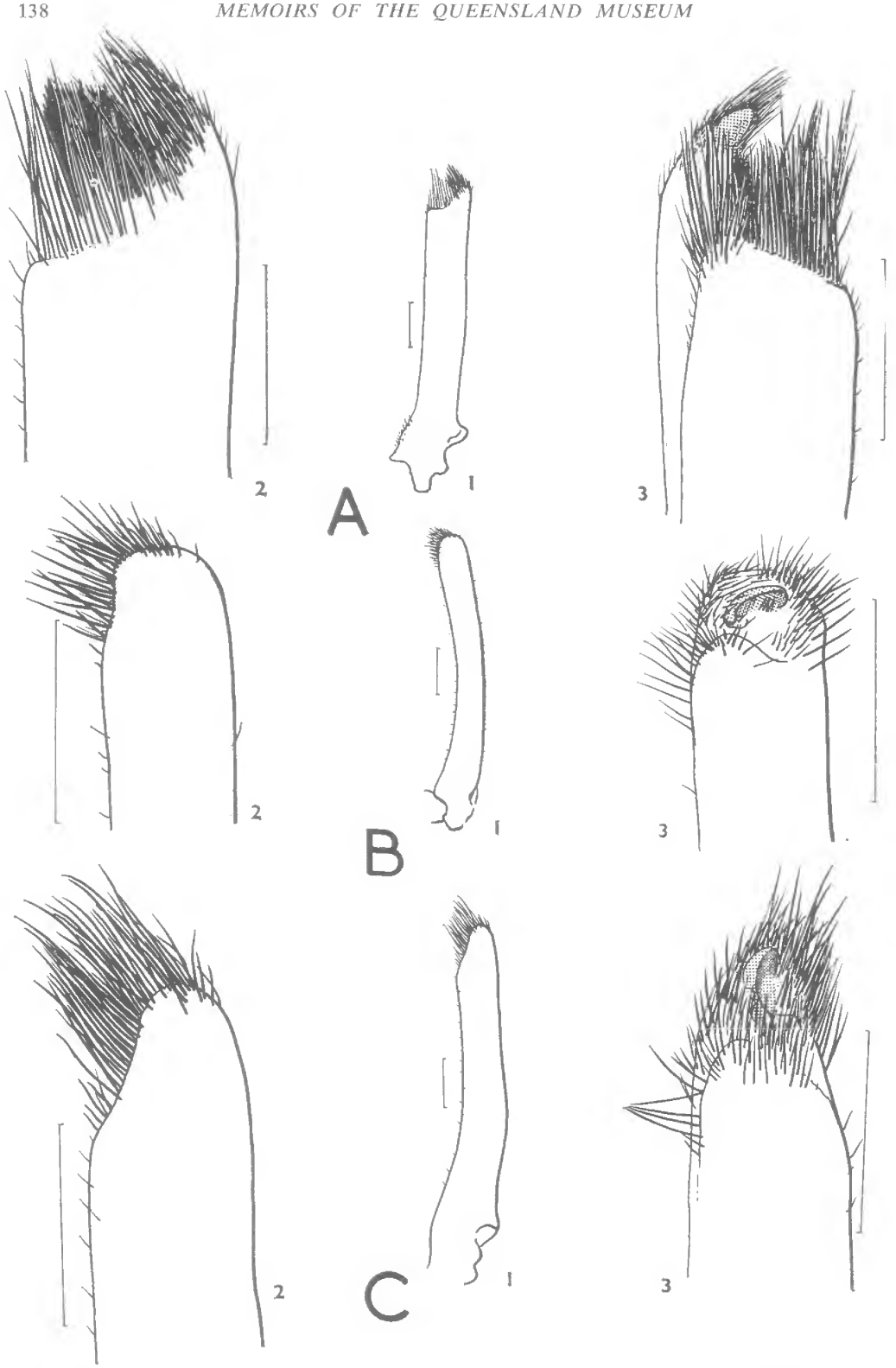
Colour.—Carapace slate olive to dark chocolate or reddish, with variable paler mottling. Upper surfaces of legs similar to carapace but with increased mottling. Dorsal surface of wrist and chela raw umber fading to cream ventrally.

Habitat

In sheltered bays and estuaries, penetrating well up river to a minimum salinity of *c.* $4^0/_{00}$ at high water. Under rocks or in burrows among grass well up in the Sesarmine zone, at or above high water level, in the river bank or well back on the mud flat. Burrows have been observed in a variety of substrates from moist clay to quite coarse, but dirty, sand. This crab is quite commonly found with *Sesarma erythrodactyla* Hess on the Queensland coast. Hale (1927a) gives full details of burrow construction by this species.

Distribution

From Brown's R., Tasmania (Tweedie, 1942) west to Port R., South Australia, and north to Pioneer R., Queensland. Although a specimen in the Queensland



Text-figure 2.—Right first male pleopods of A, *Helice leachii*; B, *Helograpsus haswellianus*; C, *Cyclograpsus insularum*. 1, Whole pleopod, abdominal surface; 2, Tip, abdominal surface; 3, Tip, sternal surface. Scale lines 1 mm.

Museum bears the locality label " ? Darnley I.", intensive collecting on the Queensland coast south of the Endeavour R. suggests that the range of this species would not extend so far north.

Not recorded from outside Australia.

Genus **CYCLOGRAPSUS** H. Milne Edwards

Cyclograpsus Milne Edwards, H., 1837, p. 77. (Type species: *Cyclograpsus punctatus* H. Milne Edwards, 1837, by subsequent designation of Rathbun, 1918).

Gnathochasmus Macleay, 1838, p. 65. (Type species by monotypy: *Gnathochasmus barbatus* Macleay, 1838 (= *Cyclograpsus punctatus* Milne Edwards, 1837)).

Diagnosis

Carapace.—Flattened posteriorly, little vaulted. Depth of carapace less than 0·6 times length. Almost smooth, regions poorly defined. Epigastric lobes generally inconspicuous. Front and anterolateral margins forming a regular curve.

Front.—Smoothly deflexed. Frontal width approximately half fronto-orbital width. Fronto-orbital width more than two-thirds width of carapace, and not much more than length. Lateral margins of front not passing imperceptibly into very oblique inner borders of orbits.

Anterolateral Borders.—Entire or microscopically notched.

Pterygostome.—With granules and setae often in orderly lines, but not conspicuously reticulate as in *Sesarma*.

Epistome.—Short, not projecting beyond front in dorsal view.

Antenna 2.—Not excluded from orbital hiatus.

Chelipeds.—Subequal, with palm swollen in adult male, often globular.

Ambulatory Legs.—Sturdy. Meri moderately broad, compressed.

Abdomen.—Seven segmented. In male not occupying whole breadth of sternum between last legs; third segment not greatly expanded laterally. Ultimate segment in mature female approximately twice as broad as long, not deeply impacted in penultimate segment.

Distribution

East and west coasts of Atlantic, Indian, and Pacific Oceans from Japan in the north to Tasmania and New Zealand in the south.

Key to the Indo-West Pacific Species of the Genus Cyclograpsus

(Species in bold face are discussed in this paper; in the case of other species a reference is given to a recent description.)

1. Anterolateral margins of carapace with 1 or 2 minute, sometimes microscopic notches 2

   Anterolateral margins entire 5

2 (1). Lateral margins of carapace straight, markedly divergent posteriorly; epigastric lobes prominent; sub-orbital ridge interrupted two or three times ..... *C. longipes* Stimpson, 1858. Bonin Islands; Atjeh, Tahiti, Tuamotu, and Fiji Islands. (See Sakai, 1939, p. 690; de Man, 1896, p. 355, pl. 32, fig. 43).

Lateral margins more or less strongly convex, not markedly divergent posteriorly; epigastric lobes obscure; sub-orbital ridge crenulate with more than 10 granules 3

3 (2). Dactyli of first and last ambulatory legs extremely short (as long as breadth of merus), with hairs at tip only..... **C. insularum** sp. nov.

Dactyli of ambulatory legs of comparatively uniform length; longitudinal rows of hairs along whole length of dactyli..... 4

4 (3). Meri of ambulatory legs smooth; sub-orbital ridge with *c.* 20 granules..... ..... *C. intermedius* Ortmann, 1894. Loo Choo Islands, Japan, Indian Ocean. (See Sakai, 1939, p. 689; 1965, pp. 200–1).

Meri with anterior and posterior edges granular; sub-orbital ridge with *c.* 11 granules ..... *C. incisus* Shen, 1940. Hong Kong. (See Shen, 1940, p. 259, figs. 10–16).

5 (1). Nearly whole of anterior half of dorsal surface of carapace distinctly and densely granular..... *C. granulatus* Dana, 1852. Hawaii. (See Edmondson, 1959, p. 188, figs. 20a, 21a, b).

Anterior third of carapace sparsely punctate and/or granular close to frontal and anterolateral margins..... 6

6 (5). Lateral borders of carapace straight, subparallel or divergent posteriorly; ambulatory propodi and dactyli with prominent scattered hairs or bristles..... 7

Lateral borders convex, convergent posteriorly; ambulatory propodi and dactyli with very short hairs (felt) only..... 8

7 (6). Sub-orbital ridge composed of 3 long lobules; front of carapace with a distinct median indentation; sides of abdomen in male almost straight..... ..... *C. integer* H. Milne Edwards, 1837. (= *C. parvulus* de Man, 1896. *fide* Forest and Guinot, 1961, 1962). Madagascar, Atjeh, Flores Sea, Marshall Is., Tuamotu, Brazil and W. Africa. (See Rathbun, 1918, p. 326, pl. 97, figs. 1, 2).

Sub-orbital ridge regularly crenulate; front of carapace straight; sides of abdomen in male distinctly concave..... *C. henshawi* Rathbun, 1902. Hawaiian Islands. (See Edmondson, 1959, p. 188, figs. 20b, 21c, d).

8 (6). Meri of ambulatory legs very broad, foliaceous, keeled..... *C. lophopus* Nobili, 1905. Red Sea. (See Nobili, 1906, p. 321, pl. 11, fig. 4).

Meri not as above..... 9

9 (8). Abdomen of male very broad, with lateral margins sub-parallel, sixth segment three times width of seventh..... *C. cinereus* Dana, 1852. Pacific American coast, Hawaiian Islands. (See Edmondson, 1959, p. 187, figs. 19a, b; Rathbun, 1918, p. 327, pl. 98).

Abdomen of male with lateral margins more or less strongly convergent to seventh segment..... 10

10 (9). Long tufts of hair arising from between bases of ambulatory legs..... 11

No long tufts of hair between bases of ambulatories..... 12

11 (10). Carpus of first ambulatory leg with felt on dorsal and anterior surfaces distally and also extending along whole length of propodus on anterior surface.....
.....**C. audouinii** H. Milne Edwards, 1837.

Carpus of first ambulatory leg naked, propodus with felt distally only.....
.....**C. lavauxi** H. Milne Edwards, 1837.

12 (10). Inner surface of palm of chela in male distinctly and densely granular medially; frontal and anterolateral parts of carapace and legs moderately to strongly granular.....**C. granulosus** H. Milne Edwards, 1853.

Inner surface of palm very weakly granular; carapace and legs smooth or only very weakly granular.....**C. punctatus** H. Milne Edwards, 1837.

It has been impossible to include *Cyclograpsus tasmanicus* Jacquinot and Lucas in the above key or to synonymise it with any of the known species of *Cyclograpsus*. Because of the brevity of the original description, the status and relationships of this species must remain uncertain.

Since the time of Dana (1852a), various authors have united the four established species discussed in this paper, *C. punctatus*, *C. audouinii*, *C. granulosus*, and *C. lavauxi* (= *C. whitei*), under the first named species which was accorded circum-subantarctic distribution (see Tesch, 1918; Balss, 1935; and Barnard, 1950). Since that time also each species has been misidentified from time to time, resulting in incorrect distributions being recorded in the literature. *C. granulosus* has never been positively identified since the time of Milne Edwards; *C. lavauxi* was recorded from Australia by Haswell (1882b) and from the Kermadec Islands by Chilton (1911), who at first, following Miers (1876), considered it conspecific with *C. whitei*, but later (Chilton & Bennett, 1929) as distinct. While Rathbun (1918) gave good reasons for separating *C. audouinii* from *C. punctatus*, Balss (1935) allowed the former only subspecific status, while Barnard (1950) considered the two as conspecific; Tesch (1918) inferred that both *C. punctatus* and *C. audouinii* occurred in Australia. The present study supports a partial return to the multiplicity of species originally envisaged by Milne Edwards (1837, 1853).

Of the characters which can be used to separate the species dealt with here, two, the pattern of felting of the ambulatory legs and the shape of the abdomen in the male, particularly of the third and sixth segments, stand out as universally applicable because of their distinctiveness. Other useful characters include the shape of the chela in the male, which is generally reliable but subject to variation, the shape of the carapace and the degree of granulation. The shape of the merus of the third maxillipeds differs little in the five species, while in all except *C. punctatus* the male first pleopod is so similar as to be virtually useless as a taxonomic character.

CYCLOGRAPSUS PUNCTATUS H. Milne Edwards

(Text-figs. 3A, 5A ; pl. 20, fig. 3 ; pl. 23, fig. 3)

Cyclograpsus punctatus Milne Edwards, H., 1837, p. 78 ; 1853, p. 197, pl. 7, figs. 9, 9a, b. Tesch, 1918, p. 126 (synon.). Rathbun, 1918, p. 328, fig. 153, pl. 99. Barnard, 1950, p. 131, fig. 24f (lit. and synon.). Garth, 1957, p. 101 (synon.)

Gnathochasmus barbatus Macleay, 1838, p. 65, pl. 3.

Sesarma barbata (Macleay). Krauss, 1843, p. 45, pl. 3, figs. 3a–c.

Cyclograpsus minutus Jacquinot, in Jacquinot and Lucas, 1852, Atlas, Crust., pl. 6, figs. 8, H ; 1853, p. 75.

Cyclograpsus Reynaudi Milne Edwards, H., 1853, p. 197.

Types

C. punctatus.—Male holotype, carapace width *c.* 31 mm, Indian Ocean, M. Reynaud ; Muséum National d'Histoire Naturelle, Paris. The right cheliped and carpus and following segments of the left third ambulatory leg are missing, but the specimen is otherwise in perfect condition.

C. reynaudi.—Male holotype, False Bay, M. Renaud ; Muséum National d'Histoire Naturelle, Paris. This specimen is intact.

Details of the types of other synonymous species and their localities are given by Rathbun (1918) and Garth (1957).

Material Examined

9 males (10·5–38 mm), 4 females (10–24·5 mm). South Africa.

Material Illustrated

Male, 38 mm, South Africa. South African Museum, Cape Town.

Description

A full description of this species lies outside the scope of this paper. Good descriptions are given by Rathbun (1918) and by Barnard (1950).

Distribution

South Africa, from Port Nolloth on the west coast to Natal on the east coast (Barnard). Chile, from Los Vilos to San Vicente, including Juan Fernandez Island (Garth).

Discussion

The form of the male first pleopod of this species (see text-fig. 5A) immediately sets it apart from any of the other species of *Cyclograpsus* discussed here. Other less marked differences are to be found in the shape of the abdomen in the male (the sixth segment being more angular), in the chela of the male (the ventral edge being more convex basally, the gape wider and the inner surface of the palm less tuberculate), and in the pattern of felting on the first and fourth ambulatory legs. The shape of the abdomen in *C. cinereus* Dana, the other Chilean *Cyclograpsus*, readily distinguishes it from *C. punctatus* (see Rathbun, 1918, pl. 98).

The specific unity of South African and Chilean specimens is attested to by Rathbun, who examined specimens from both areas; attempts by us to obtain Chilean material have been unsuccessful. This species was recorded by Stimpson (1907) from Hong Kong; the locality is quoted by Rathbun (1918) without comment, but its existence there seems doubtful.

The restricted synonymy given of this species includes only the first descriptions of synonymous species and basic references to later treatments.

CYCLOGRAPSUS LAVAUXI H. Milne Edwards

(Text-figs. 3B, 5B; pl. 20, fig. 4; pl. 23, fig. 4)

Cyclograpsus audouinii H. Milne Edwards. Dana, 1852b, p. 359, pl. 23, fig. 2.

(non) *Cyclograpsus audouinii* Milne Edwards, H., 1837, p. 78.

Cyclograpsus lavauxi Milne Edwards, H., 1853, p. 197.

Cyclograpsus lavauxi H. Milne Edwards. Miers, 1876, p. 41. Filhol, 1886, p. 390, pl. 41, figs. 4–6. Thomson, 1913, p. 238. Chilton and Bennett, 1929, p. 770. Richardson, 1949, p. 34 (in key). Bennett, 1964, p. 84, figs. 98–100.

Cyclograpsus Whitei Milne Edwards, H., 1853, p. 197. Filhol, 1886, p. 391.

Types

C. lavauxi.—Male lectotype (J. Forest), carapace width *c.* 23 mm, New Zealand, M. Lavaux; Muséum National d'Histoire Naturelle, Paris. This specimen lacks the right second and left first ambulatory legs but is otherwise in excellent condition.

C. whitei.—Female holotype, carapace width *c.* 27 mm, New Zealand; Muséum National d'Histoire Naturelle, Paris. The carapace of this specimen is slightly cracked on the dorsal surface close to the midline posteriorly, but otherwise in excellent condition.

Material Examined

11 males (13–20 mm), 11 females (8·5–18 mm).

New Zealand : Sandy Beach (Bay of Islands), Waiheke Is., (Auckland), Waihau B., (eastern Bay of Plenty), Waitere Beach, (Levin), Kau Pt. and Island B., (Wellington), Palling Pt. (Otago Harbour).

Material Illustrated

Male, 20 mm, Island Bay, Wellington, 30. iii. 1947, R. K. Dell. Dom. Mus., Wellington.

Description

Carapace.—Broader than long, widest about $\frac{1}{4}$ carapace length from front, posterolateral margins subparallel. Surface smooth or very weakly granular anterolaterally and close to frontal margin. A microscopically granular elevated ridge extending around margins.

Regions poorly defined, gastrocardiac groove prominent. Punctulations absent except for a shallow one anterolaterally, midway between external orbital angle and gastrocardiac groove.

Lateral margins entire.

Orbits uniformly concave to subquadrate, junction with front sharp, posterior border transverse to sloping obliquely posterolaterally ; outer angle a sharp point, not advanced as far as level of front.

Front well deflexed, barely visible in dorsal view, convex to weakly bilobate, median frontal furrow prominent, extending to opposite widest part of carapace.

Sub-orbital ridge strongly granular, granules 10–17 in number, most commonly 13–15, irregular in size.

Chelipeds.—Carpus smooth except for a minutely granular area at dorsomedial angle.

Chela of male longer than deep, compressed, dorsal and ventral edges of palm subparallel, surface smooth except for a strongly granular longitudinal ridge medially on inner face of palm. Ventral edge of chela straight or very weakly concave at base of fixed finger. Fingers gaping as an almost right angled triangle for about basal third, narrow and linear beyond this, dentition weak, uniform ; fixed finger weakly convex midway along inner edge, weakly concave distally.

Ambulatory Legs.—Long, moderately robust, compressed, second leg about 1·5 times carapace width, surfaces generally smooth ; dactyli long and slender.

First leg with carpus naked. Propodus moderately felted on dorsal surface for distal half, anterior surface with slender medial line of felt for about the distal half of the segment, shorter and even more slender indistinct rows anteroventrally and posteroventrally. Dactyli with 6 distinct, slender longitudinal rows of felt for entire length, three dorsal ones wider than others.

Second and third legs with propodi bearing a distal transverse row of felt dorsally, dactyli with 6 rows of felt as in first leg.

Last leg with carpus naked. Propodus with a short row of felt on dorsal surface extending for distal two-thirds, widening distally. Dactyl with 6 rows of felt, 3 dorsal very wide, hardly distinct, others very sparse.

Moderately long tufts of hair arising from between bases of first and second, and second and third ambulatories, absent from between third and fourth.

STERNUM.—Anterior 2 segments very sparsely pubescent, second segment almost naked.

MALE ABDOMEN.—Third segment convex laterally or with edges almost straight and widening slightly distally to just short of distal edge ; following segments tapering to base of sixth segment, sides of which are strongly convex, subparallel for basal half, distally tapering, junction of basal and distal portions smoothly rounded. Seventh segment much narrower than sixth, wide basally, distally rounded.

COLOUR.—Carapace pale yellow dorsally, mottled red anteriorly ; legs similar with irregular red mottling dorsally ; undersides of carapace and legs, both outer and inner surfaces of chelae, pale.

HABITAT

On stony or sandy beaches, under logs or stones, throughout the littoral. According to Richardson (1949), this species is found in the lower part of the intertidal zone.

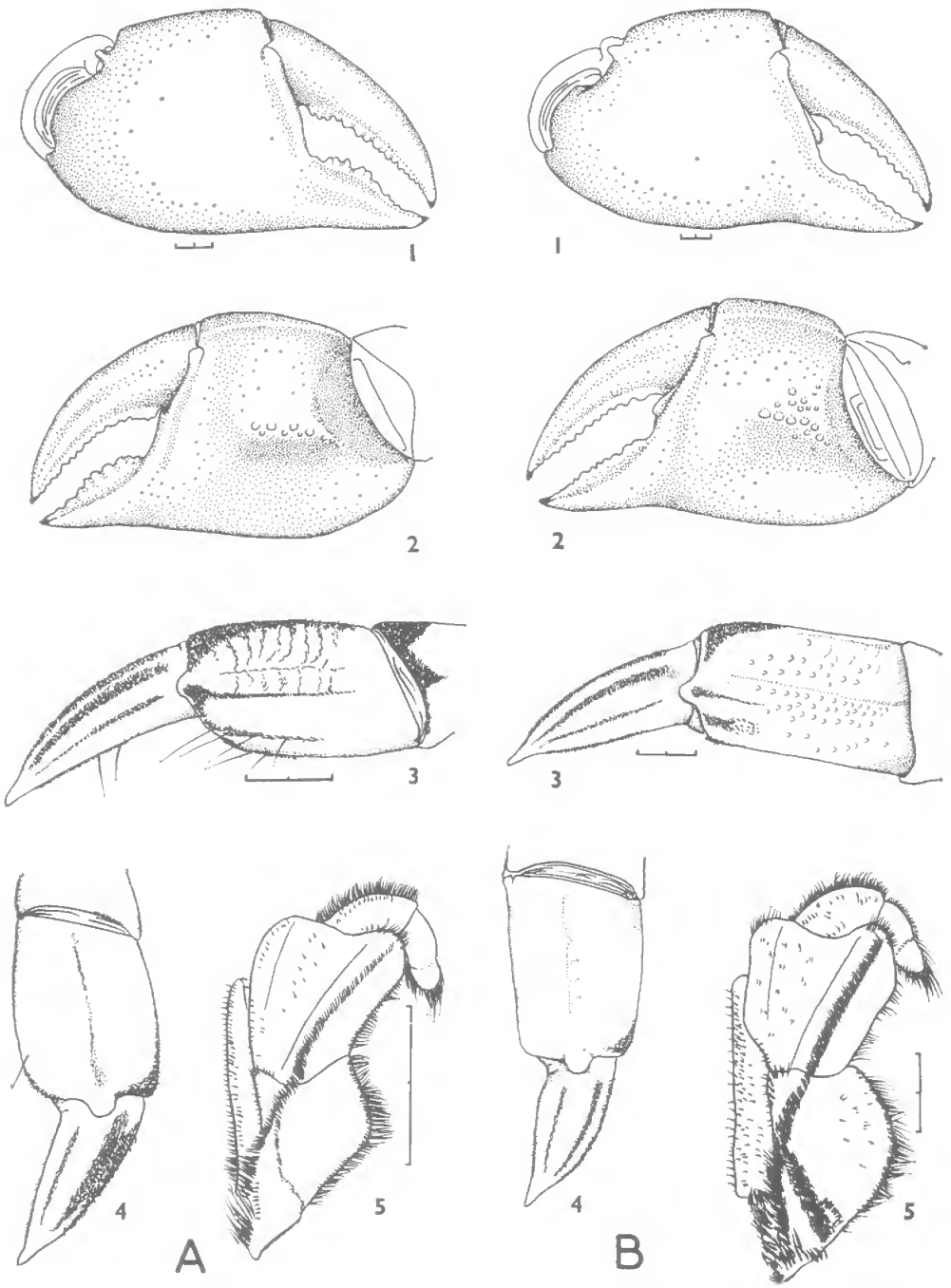
DISTRIBUTION

Throughout New Zealand, from Bay of Islands in the north to Otago Harbour in the south ; not extending outside New Zealand.

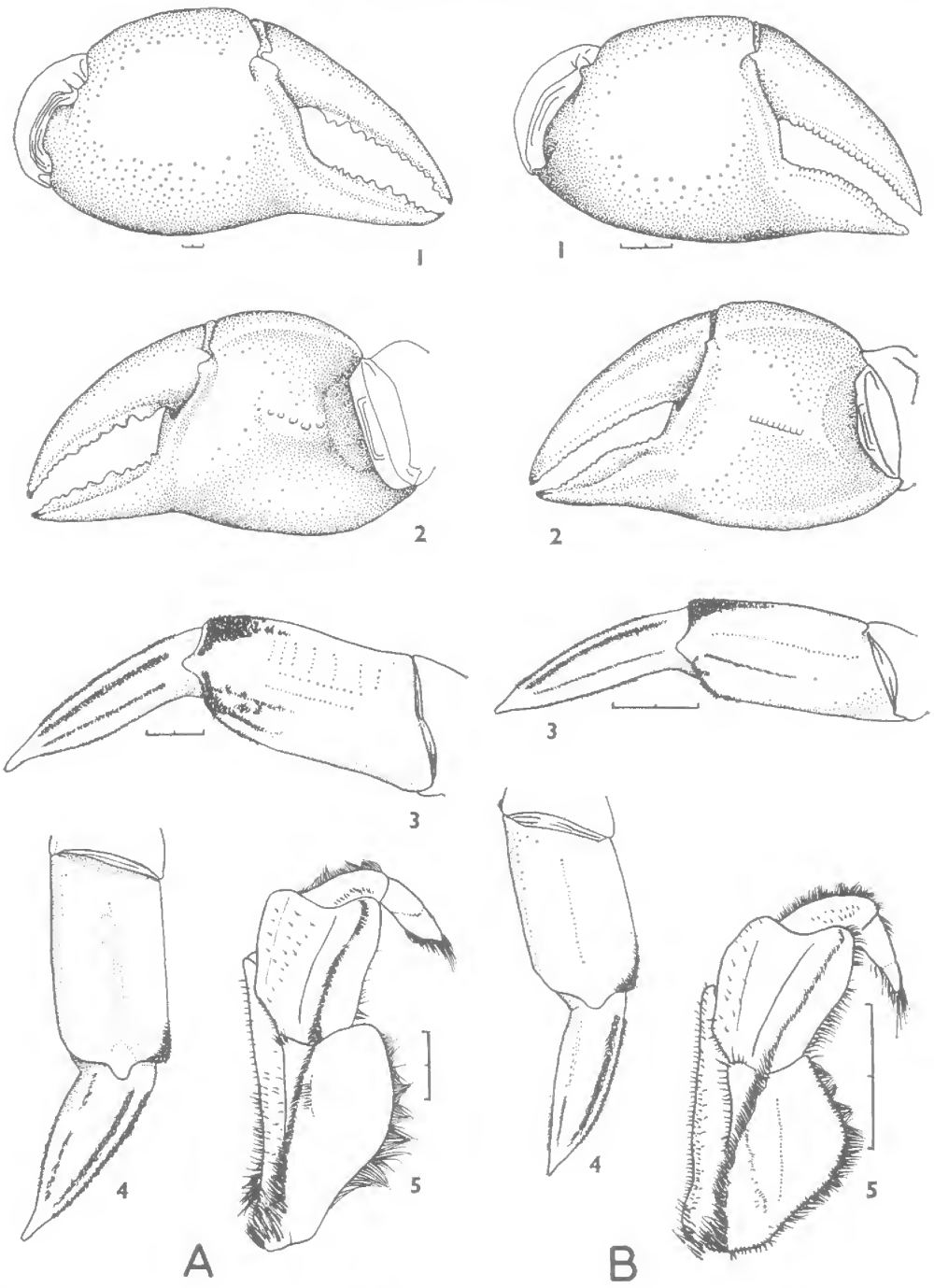
DISCUSSION

Examination of photos of the male lectotype of *C. lavauxi* and of the female holotype of *C. whitei* strongly suggests that the two are in fact conspecific, as Chilton (1911) and students of the New Zealand Crustacea before him considered. Certainly, the descriptions given of the two species by Milne Edwards (1853) were not adequate enough to distinguish the two. However, when confronted by a large series of specimens, Chilton & Bennett (1929) recognised two species and must naturally have assumed that one was *C. whitei*. The characters attributed to the latter species by Chilton & Bennett do not exist in the holotype of *C. whitei*, but typify the new species described here, *C. insularum*. The specific name *lavauxi* has line preference over *whitei*.

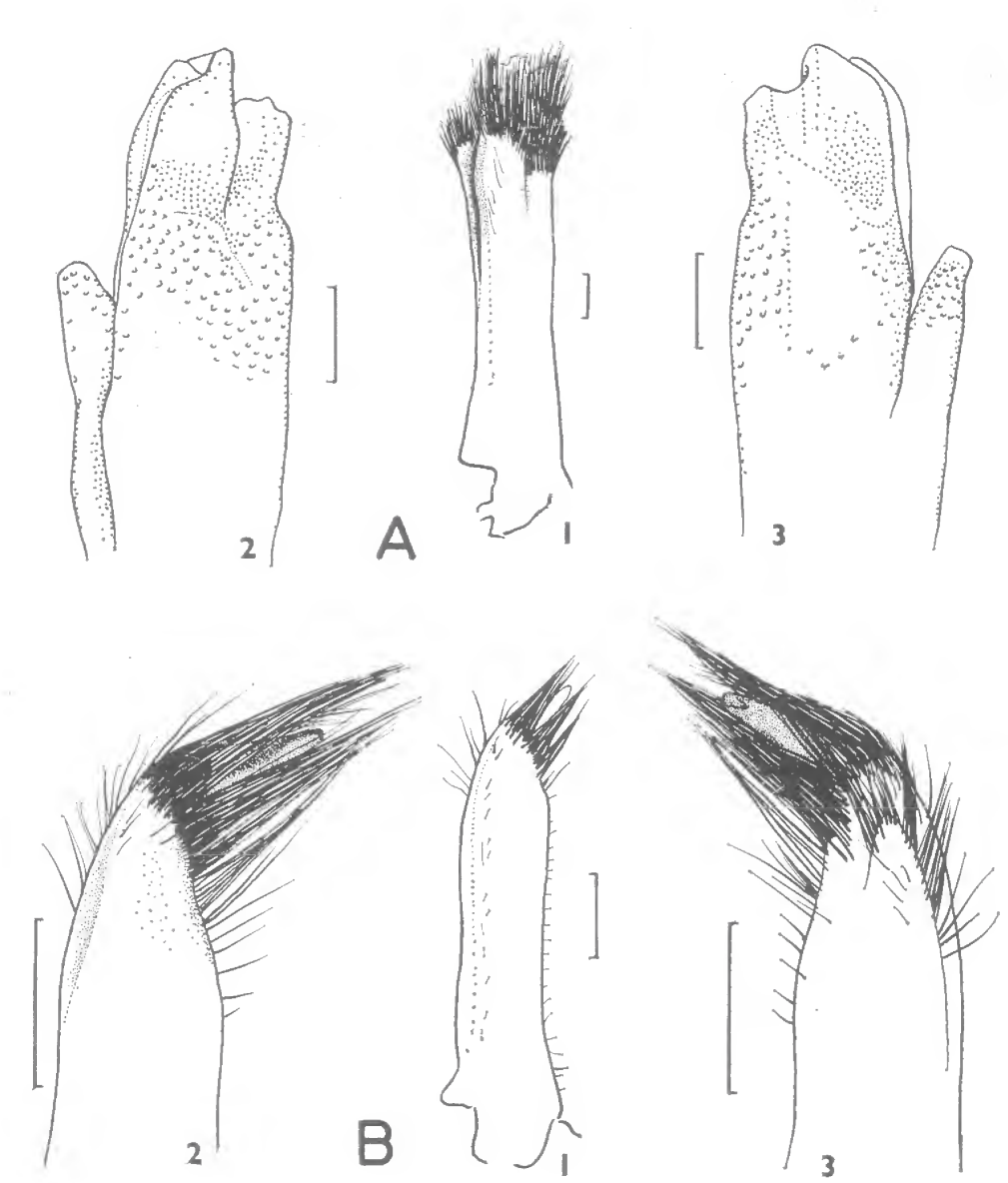
Several New South Wales specimens referable to *C. audouinii* are very similar to some specimens of *C. lavauxi* in a few characters. For instance, the basal portion of the lateral margin of the sixth segment of the abdomen in the male widens slightly from the base instead of tapering, the third segment in some *C. lavauxi* also widens from the base as is typical in *C. audouinii* ; the shape of the chela in the male is also similar. However, the pattern of felting of the ambulatory legs is strikingly different in all specimens of the two species.



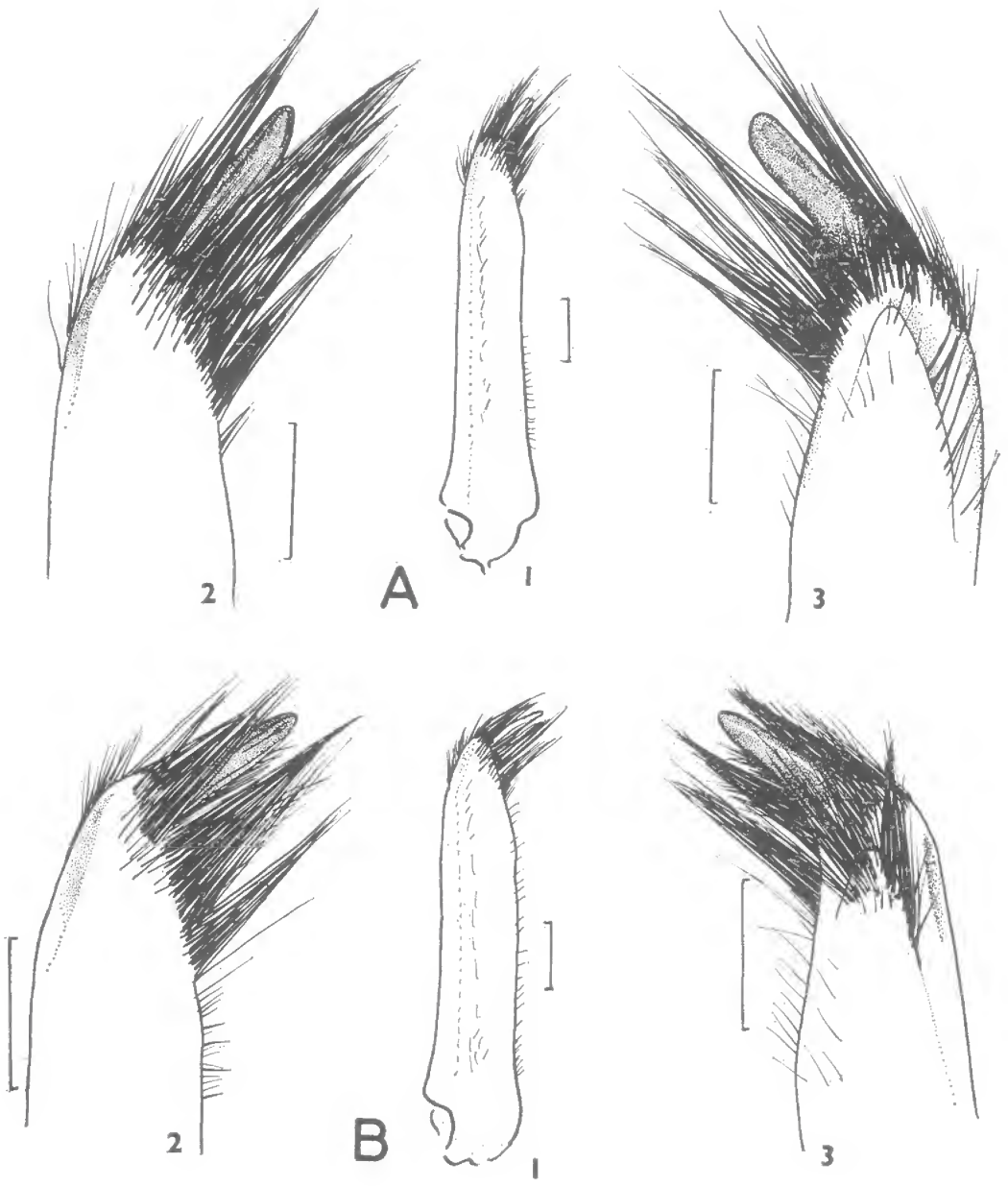
Text-figure 3.—A, *Cyclograpsus punctatus*; B, *C. lavauxi*. 1, Chela, outer face; 2, Chela, inner face; 3, Right first walking leg, anterior face; 4, Right last walking leg, posterior face; 5, Third maxilliped. Scale lines 2 mm.



Text-figure 4.—A, *Cyclograpsus audouinii*; B, *C. granulosus*. 1, Chela, outer face; 2, Chela, inner face; 3, Right first walking leg, anterior face; 4, Right last walking leg, posterior face; 5, Third maxilliped. Scale lines 2 mm.



Text-figure 5.—Left first male pleopods of A, *Cyclograpsus punctatus*; B, *C. lavauxi*. 1, Whole pleopod, abdominal surface; 2, Tip, abdominal surface; 3, Tip, sternal surface. For figs. A. 2, 3, the tip has been denuded to show sculpturing. Scale lines 1 mm.



Text-figure 6.—Left first male pleopods of A, *Cyclograpsus audouinii*; B, *C. granulosus*. 1, Whole pleopod, abdominal surface; 2, Tip, abdominal surface; 3, Tip, sternal surface. Scale lines 1 mm.

CYCLOGRAPSUS AUDOUINII H. Milne Edwards

(Text-figs. 4A, 6A ; pl. 21, figs. 1, 2 ; pl. 23, figs. 5, 6)

Cyclograpsus Audouinii Milne Edwards, H., 1837, p. 78 ; 1853, p. 197.

Cyclograpsus audouinii H. Milne Edwards. Stimpson, 1907, p. 132. Tesch, 1918, p. 126. Hale 1924, p. 70 ; 1927a, p. 176, fig. 176 ; 1927b, p. 312. Montgomery, 1931, p. 456.

(non) *Cyclograpsus audouinii* H. Milne Edwards. Edmondson, 1925, p. 56 (= *C. integer* H. Milne Edwards).

Cyclograpsus laevis Hess, 1865, p. 152 (type-locality : Sydney). De Man, 1887, p. 700.

Cyclograpsus lavauxi H. Milne Edwards. Haswell, 1882b, p. 103.

(non) *Cyclograpsus lavauxi* Milne Edwards, H., 1853, p. 197.

Cyclograpsus punctatus H. Milne Edwards. Ortmann, 1894a, p. 729 (part : Sydney specimens only).

(non) *Cyclograpsus punctatus* Milne Edwards, H., 1837, p. 78.

Cyclograpsus punctatus audouinii H. Milne Edwards. Balss, 1935, p. 142.

TYPE

C. audouinii.—Male lectotype (J. Forest), carapace width *c.* 27 mm, New Guinea, MM. Quoy and Gaimard ; Muséum National d'Histoire Naturelle, Paris. The dorsal surface of the carapace is badly damaged and the right fourth ambulatory leg has the propodus and dactyl missing while the left third ambulatory has the carpus and following segments missing ; the specimen is otherwise intact.

MATERIAL EXAMINED

142 males (6·5–40·5 mm), 92 females (5–28 mm).

QUEENSLAND : Mouth of Elliott R., Hervey B., Noosa. NEW SOUTH WALES : Port Macquarie, 2m. S. of Tuggerah Lakes, Pittwater (Broken B.), North Harbour (Manly), Little Sirius Cove and Mosman B. (Port Jackson), Coogee, Botany B., Winday I. (Lake Illawara), Wollongong, Shell Harbour. SOUTH AUSTRALIA : Flinders I., St. Vincent's Gulf. WEST AUSTRALIA : Salmon B. (Rottnest I.), Freshwater B., Pt. Peron, Cottesloe B., Cowaramp B., Koombana B. (Bunbury), Duke of New Orleans B., Oyster Harbour (Albany), Woodmans Pt., Pallinup Estuary, Christmas I. and Middle I. (Recherche Archipelago).

MATERIAL ILLUSTRATED

Males, 25, 26·5 mm, Woodmans Pt., Groyne, W.A., 13. xii. 1959, W.A. Nats. Excursion., W.A. Mus. 203.62 (text-figs. 4A, 1, 2 ; 6A).

Male, 22 mm, Mosman B., Port Jackson, N.S.W., Dec. 1908, T. Whitelegge. Aust. Mus. P.1840 (text-figs. 4A, 3, 4).

Males, 17, 18·5 mm, Noosa, Qld., Jan., 1963, B.C. (text-figs. 4A, 5 ; pl. 21, fig. 1 ; pl. 23, fig. 5).

Male, 26 mm, Woodmans Pt., Groyne, W.A., 13. xii. 1959, W.A. Nats. Excursion. W.A. Mus. 203.62 (pl. 23, fig. 6).

Male, 40·5 mm, St. Vincents Gulf, S.A., South Australian Mus. (pl. 21, fig. 2).

Description

Carapace.—Broader than long, lateral margins almost uniformly convex, widest close to half carapace length from front. Surface smooth or very finely granular around anterolateral margins and front only. A microscopically granulate ridge extending around frontal and lateral margins.

Regions poorly demarcated, gastro-cardiac groove prominent. Several punctulations anterolaterally and posteromedially.

Lateral margins entire.

Front moderately deflexed, clearly visible from above, transverse to uniformly convex or bilobate, median frontal furrow extending to just behind orbits.

Orbits almost uniformly concave in dorsal view, junction with front a definite angle (*c.* 90°), laterally raised and sharply pointed, posterior border transverse.

Sub-orbital ridge strongly and distinctly granular, composed of 13–21 granules, most commonly 17.

Chelipeds.—Carpus smooth except for minutely granular narrow portion dorsomedially.

Chela of male longer than deep, compressed, palm enlarged distally, surface smooth except for ridge of strong granules on raised swelling extending longitudinally along inner surface of palm medially. Ventral edge straight or very weakly concave at junction of fixed finger. Fingers widely gaping basally, dentition strong in both fingers, toothed inner edge of fixed finger strongly convex midway along, weakly concave distally.

Ambulatory Legs.—Long (second leg almost 1·5 times carapace width), moderately robust, compressed, surfaces generally smooth.

First leg with carpus and following segments densely felted, especially on anterior surfaces ; carpus with broad band of felt along distal edge usually extending proximally as two very short rows, 1 dorsal and 1 medial ; propodus with two dense longitudinal rows, 1 dorsal and 1 medial, extending for almost entire length and joined by fine lines, in addition 2 short rows of felt, 1 anteroventral and 1 posteroventral ; dactyl with 6 longitudinal rows, 3 dorsal wider than others.

Second and third legs naked except for a single fine mid-dorsal row of felt on propodus and 6 rows on dactyl as in first leg.

Last leg with carpus often bearing a slender mid-dorsal row of felt, propodus with a strong row of felt mid-dorsally, widening distally, dactyl with 6 rows of felt, dorsal 3 extremely wide, hardly separated.

Long tufts of hair between bases of ambulatory legs arising from antero-ventral and posteroventral surfaces of bases, tufts equally long between first and second and second and third legs.

Sternum.—Anterior 2 segments generally strongly hirsute, hairs clumped anteromedially anterior to, and around anterior margin of, abdominal fossa.

Male Abdomen.—Third segment convex laterally or widening slightly from base to just short of distal edge, the widest part of the abdomen. Following segments tapering to base of sixth, the sides of which are basally subparallel or narrowing slightly, distally straight, junction of basal and distal portions sharp or smoothly rounded. Seventh segment with sides concave basally, rounded distally.

Colour.—Carapace dorsally brownish purple, very often darker anteriorly than posteriorly ; legs similar in colour with paler markings, chelae pale on outer and inner surfaces ; undersides of carapace and legs pale. Specimens from mud-flats and reefs often mottled with purple, dark grey or brownish-grey (Hale, 1927a, modified).

Habitat

Among heaped boulders and stones at or above highest tide limit, extending into shallow water, often in association with seaweed or logs, on rocky platforms, beaches and on reefs and estuarine flats (Hale, 1927a ; McNeill, 1962 ; R. W. George, pers. comm.). Both Hale and McNeill state that this species can survive long periods out of water.

Distribution

Australia, excluding Victoria and Tasmania, from Shark Bay in the north-west to Hervey Bay in the north-east ; New Guinea.

Discussion

The distinctions between this and other species are discussed under *C. granulosus* and *C. lavauxi*.

Through the kindness of Edwin H. Bryan Jr. of the Bernice P. Bishop Museum, Honolulu, it has been possible to examine four specimens (two males and two females) from the material recorded from Wake Island, N.W. Pacific Ocean by Edmondson (1925, p. 56) as *C. audouinii*. These specimens prove to belong to *C. integer* H. Milne Edwards.

Two specimens (a small male and female, P.1702) in the Australian Museum collections, referable to this species, bear the locality label " Tasmania, Dec. 1908, Old Collection ". No other collections from Tasmania contain this species so it appears highly likely that the label is erroneous.

CYCLOGRAPSUS GRANULOSUS H. Milne Edwards

(Text-figs. 4B, 6B ; pl. 21, fig. 3 ; pl. 23, fig. 7)

Cyclograpsus granulosus Milne Edwards, H., 1853, p. 197. Haswell, 1882b, p. 104. Guiler, 1952, p. 40.

Cyclograpsus punctatus H. Milne Edwards. Haswell, 1882b, p. 104, Guiler, 1952, p. 40 ; 1956, p. 7.

(non) *Cyclograpsus punctatus* Milne Edwards, H., 1837, p. 78.

Cyclograpsus audouinii H. Milne Edwards. Tweedie, 1942, p. 18, fig. 4.

(non) *Cyclograpsus audouinii* Milne Edwards, H., 1837, p. 78.

Type

Female lectotype (J. Forest), carapace width *c.* 22 mm, Tasmania, MM. Quoy and Gaimard ; Muséum National d'Histoire Naturelle, Paris. Specimen complete and in good condition.

Material Examined

86 males (7–35 mm), 59 females (8·5–28·5 mm).

South Australia : Kingsgote and Shoal Bay (Kangaroo Island). Victoria : Beaumaris, Appollo B., Lady B., Bass Strait : Frazer B. and S. of Currie Harb. (King Island), Goose Island. Tasmania : Stanley, Ulverstone, Hawley Beach (Devonport), Low Head, Bicheno, Coles B., Meredith R., Orford, Rheban, Eaglehawk Neck (inner bay), Pirates B., Derwent R. (Bellerive, Sandy B., Taroona), Kingston, Blackman's B., Howden, Oyster Cove, Gordon, Falmouth.

Material Illustrated

Male, 29 mm, Rheban, Tas., 17. vi. 1962, D.J.G.G., Tas. Mus. G.1076. (text-figs. 4B, 1, 2, 5).

Male, 35 mm, Goose I., Bass Strait, 19. vi. 1954, pres. Miss I. Bennett, Aust. Mus. P.12450 (part). (text-figs. 4B, 3, 4).

Male, 27 mm, Sandy Bay Rivulet, Tas., 13. vii. 1962, D.J.G.G., Tas. Mus. G.1077. (text-fig. 6B ; pl. 23, fig. 3).

Male, 31·5 mm, Victoria, National Museum of Victoria. (pl. 21, fig. 3).

Description

Carapace.—Broader than long, lateral margins strongly divergent anteriorly, widest about one-third carapace length from front, posteriorly weakly convergent. Surface very strongly granular anteriorly, around anterolateral margins and front. A finely beaded, elevated ridge extending around frontal and lateral margins.

Regions generally poorly defined. Gastrocardiac groove prominent, cervical groove weak, cardiac and intestinal regions weakly demarcated. Several punctulations or shallow depressions anteriorly at posterior part of hepatic region, centrally at each end of gastrocardiac groove, and posteriorly lateral to intestinal regions.

Lateral margins entire.

Front moderately deflexed, clearly visible from above, strongly bilobate or sometimes quadrilobate, median frontal furrow extending posteriorly almost to opposite widest part of carapace. Orbits almost uniformly concave in dorsal view, junction with front sharp, almost a right angle ; lateral angle raised as a sharp triangular tooth ; posterior border transverse to oblique, sloping posterolaterally.

Sub-orbital ridge strongly and distinctly granular, composed of 12–19 granules, most commonly 16.

Chelipeds.—Carpus smooth, except for narrow minutely granular area dorso-medially.

Chela of male longer than high, enlarged distally, compressed, surface smooth except for a ridge of strong granules on raised swelling extending longitudinally along inner surface of palm medially, the swelling itself less strongly granular. Ventral edge generally strongly concave at junction of fixed finger. Fingers weakly gaping basally except in very large males where the fingers gape for their entire length ; gape linear. Dentition strong in both fingers, toothed inner edge of fixed finger straight.

Ambulatory Legs.—Moderately robust, long, compressed, second leg almost 1·5 times carapace width, surfaces weakly pitted and finely granular dorsally.

First leg with carpus naked ; propodus distally felted on anterior surface, dorsally a triangle of felt widening distally extending half length of segment, a narrow row of felt medially and two smaller rows ventrally, 1 anteroventral and 1 posteroventral ; dactyl with 6 longitudinal rows of felt, 3 dorsal ones wider than ventral.

Second and third legs naked except for fine rows of felt on dactyl.

Last leg with carpus naked ; propodus naked except for short distal triangular area of felt dorsally as on first leg ; dactyl with 6 rows of felt, dorsal 3 very broad, others slender.

Bases of ambulatories bearing very short hairs which do not protrude between legs as tufts.

Sternum.—Anterior segments generally weakly hirsute or naked.

Male Abdomen.—Third segment laterally convex or narrowing from base, widest part of abdomen. Following segments tapering to base of sixth. Sixth segment hexagonal, lateral borders subparallel for basal half or weakly convergent, distally strongly convergent to just short of distal margin ; junction of basal and distal portions sharp to smoothly rounded. Seventh segment slightly longer than wide with subparallel to weakly convergent margins, distally rounded.

Colour.—Carapace deep red or purple to brownish red, sometimes with paler yellowish mottling, especially posteriorly ; legs with similar colouring, chelae pale yellow to white on both outer and inner faces, undersides of carapace and legs pale.

Habitat

On boulder or shingle beaches on sheltered to fully exposed coasts under stones, often near masses of seaweed in the upper part of the midlittoral or above high tide mark.

Distribution

Tasmania and Victoria, extending westward to Kangaroo Island, South Australia.

Discussion

Apart from the differences in the pattern of felting of the ambulatory legs, this species may be distinguished from *C. audouinii* in the following characters :

1. Carapace shape.—In *C. granulosus* generally widest closer to the front than in *C. audouinii*, the anterolateral margins more widely flaring from the outer orbital angle.

2. Granulation.—The dorsal surface of the carapace, especially anteriorly, and the legs, are generally distinctly granular in *C. granulosus* but smooth or only minutely granular in *C. audouinii*.

3. Front.—Often quadrilobate in *C. granulosus* and longer than the anterolateral margin ; usually bilobate or uniformly convex in *C. audouinii* and shorter than the anterolateral margin.

4. Sternum and third maxillipeds.—Much less hairy in *C. granulosus*.

5. Male chela.—In *C. granulosus* the ventral edge is generally strongly concave at the base of the fixed finger rather than straight as in *C. audouinii*, the gape is linear and moderate rather than wide, with the inner edge of the fixed finger almost straight instead of strongly convex midway along and the ridge of the inner surface of the palm is more densely granular in *C. granulosus*.

6. Bases of ambulatory legs.—The absence in *C. granulosus* and the presence in *C. audouinii*, of strong tufts of hair between the bases of the ambulatories completely distinguishes these two species.

7. Male abdomen.—While generally distinctive in the two species, the third segment is sometimes laterally convex in both, and the sixth segment almost hexagonal with the sides subparallel basally or slightly tapering. However, in *C. granulosus* the distal portion of the sixth segment is weakly concave whereas in *C. audouinii* it is straight.

8. Male first pleopod.—In *C. granulosus* the horny tip is straight and pointed with a slender aperture on the abdominal surface, while in *C. audouinii* the tip is weakly curved and rounded with a prominent aperture on the sternal surface.

In samples from near the boundaries of their distributions there is much less variation between specimens and the distinguishing characters are much better developed than in samples from widely separated areas. For instance, specimens of *C. audouinii* from South Australia and of *C. granulosus* from Victoria are more easily distinguishable from each other than are Western Australian specimens of *C. audouinii* and Tasmanian specimens of *C. granulosus*.

It is probable that the range of this species coincides with the Maugean cool-temperate province as defined by Bennett & Pope (1953).

CYCLOGRAPSUS INSULARUM sp. nov.

(Text-figs. 2C, 7 ; pl. 21, fig. 4 ; pl. 23, fig. 8)

Cyclograpsus lavauxi H. Milne Edwards. Chilton, 1911, pp. 560–1.

(non) *Cyclograpsus Lavauxi* Milne Edwards, H., 1853, p. 197.

Cyclograpsus whitei H. Milne Edwards. Chilton and Bennett, 1929, pp. 769–70. Bennett, 1964, p. 85, figs. 101–2, 139.

(non) *Cyclograpsus Whitei* Milne Edwards, H., 1853, p. 197.

Epigrapsus politus Heller. Lenz, 1901, p. 471.

(non) *Epigrapsus politus* Heller, 1862, p. 522.

Material Examined

Holotype : Male, 22 mm, under basalt boulders on surf beach, Little Slope, Lord Howe I., A. R. McCulloch, 2. iii. 1921. Australian Museum, P.5263.

Paratypes : Australian Museum, Sydney.—seven males (7–14 mm), two females (9, 15 mm), same data as holotype, P.5264. Male (12 mm), female (14 mm)—Norfolk I., Mrs. F. E. Grant, Feb. 1907, dry pres., G.5880. Three females (11–15 mm)—Lord Howe I., " Thetis " Expedition, Dec. 1908, P.1644. Two males (12, 15 mm), male (12 mm)—Lord Howe I., " Thetis " Expedition, Dec. 1908, P.1645. Two males (14, 15 mm)—on reef, Lord Howe I., A. R. McCulloch, Oct. 1908, P.1134.

Dominion Museum, Wellington. Four males (8–15 mm), female 13 mm, Denham Bay, Raoul I., Kermadec I., Miss P. Bergquist, June 1956.

Canterbury Museum, Christchurch. Three males (14–19 mm), four females (11–18 mm) " New Zealand, C. Chilton." (Identified by Chilton and Bennett, 1929, as *C. whitei* Milne Edwards.)

Material Illustrated

Holotype.

Description

Carapace.—Broader than long (*c.* 1·2 times), quite flat dorsally. Surface very smooth, microscopically punctate, sometimes granulate laterally. A very faintly granulate rim extending around lateral and frontal margins.

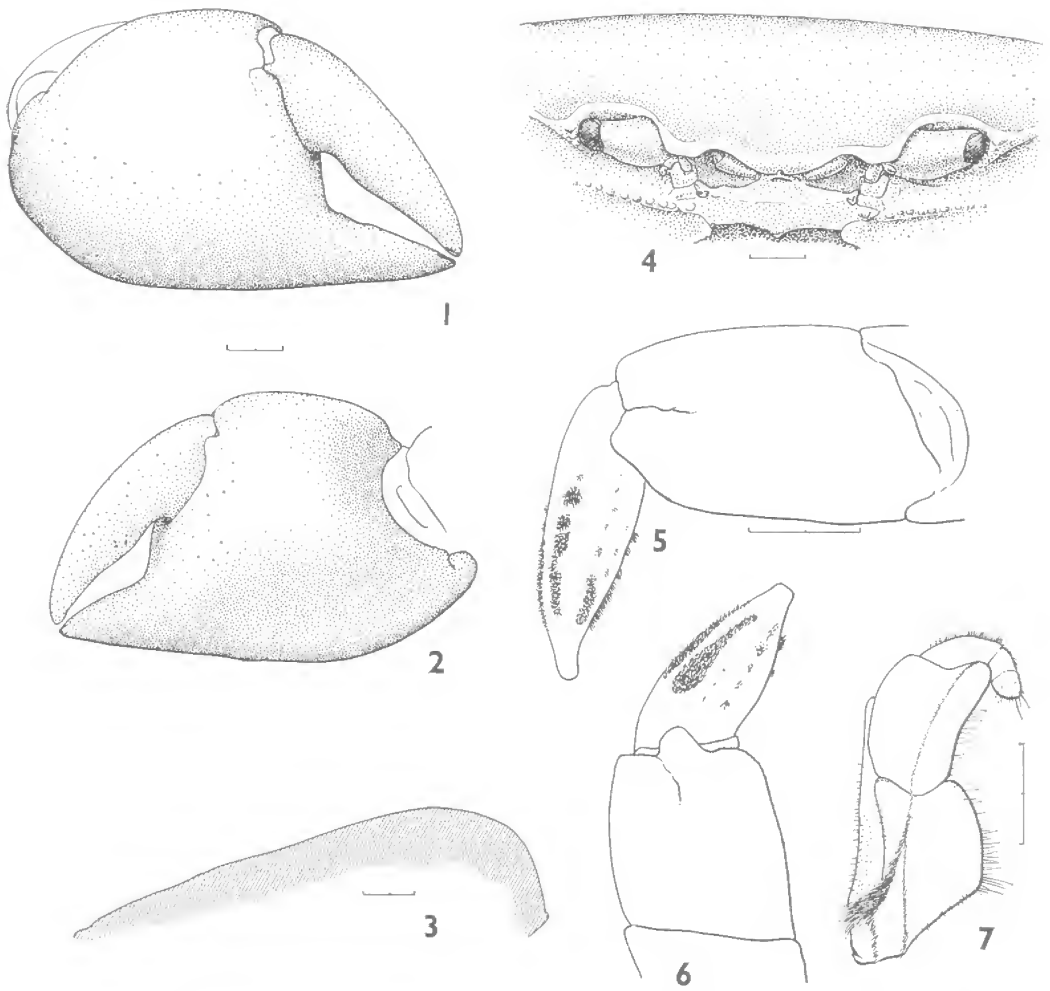
Gastric regions not defined. Frontal furrow absent. Gastrocardiac groove shallow. Cardiac regions not defined, or indicated only by aggregation and elongation of punctae.

Anterolateral borders usually twice microscopically interrupted, with shallow grooves leading inwards from the interruptions, of which the more posterior is less distinct, sometimes absent.

Orbits very small, less than half frontal width, with outer angle not projecting. Frontal area (and anterolateral region anterior to first pair of anterolateral notches) curving abruptly downwards, frontal region at right angles to rest of carapace. In anterior view frontal border is characterised by deep indentations for first antennae on either side of notched median ventral extension.

Sub-orbital crest consisting of some 15 tubercles, largest beneath orbit, decreasing in size laterally.

CHELIPEDS.—Carpus smooth and rounded. In smaller specimens inner angle projecting sharply, appearing spinous in ventral view. Inner angle rounded in large specimens.



Text-figure 7.—*Cyclograpsus insularum*. 1, Chela, outer face; 2, Chela, inner face; 3, Median longitudinal section of carapace; 4, Front; 5, Right first walking leg, anterior face; 6, Right last walking leg, posterior face; 7, Third maxilliped. Scale lines 2 mm.

Chela of male with all surfaces smooth, devoid of granules or ridges. Dentition low, sometimes obsolescent. Dentition in female distinct, regularly serrate.

Ambulatory Legs.—Robust, with segments swollen. Second leg a little more than 1·5 times carapace breadth. Merus finely granulate, especially on anterior and posterior borders. All legs naked except for rows of sparse tufting on dactyli, and scattered long bristles on posterior margins of propodi.

Last leg with propodus little longer than broad, dactyl as long as propodus, twice as long as broad.

No tufts of hair between bases of ambulatory legs.

Sternum.—Hirsute between tip of abdomen and base of maxillipeds, hairs tending to form transverse parallel rows.

Male Abdomen.—Evenly tapering (only slightly concave laterally) from proximal border of third segment to distal quarter of sixth segment, then sharply incurving to the terminal segment which is paraboloid, almost as long as broad.

Colour.—All available specimens alcohol bleached.

Distribution

Kermadec I. (Chilton, 1911), New Zealand (Chilton and Bennett, 1929), and now Lord Howe I. and Norfolk I.

Discussion

As was mentioned under *C. lavauxi*, Chilton and Bennett (1929) recorded this species as *C. whitei* which is here considered a synonym of *C. lavauxi*. *C. lavauxi* (and the type of *C. whitei*) differs from the present species in that the carapace is transversely vaulted, there is an obvious median frontal furrow, the lateral margins of the orbits project anteriorly, the front does not show the characteristic indentations for the first antennae, and the dactyl of the last leg is more slender.

Balss (1935, p. 143) states that the specimens from French Pass in New Zealand referred by Lenz (1901) to *Epigrapsus politus* Heller in fact belong to *Cyclograpsus whitei* H. Milne Edwards. *E. politus* Lenz (not of Heller) presumably therefore becomes a synonym of *C. insularum* (see also Bennett, 1964, p. 85).

The present species is very close both to *C. intermedius* Ortmann and to *C. incisus* Shen. These three, plus *C. longipes* Stimpson (in which, however, the carapace is narrowed anteriorly, the areas well defined, and the sub-orbital ridge composed of but 3 to 4 tubercles) form a well defined subgroup within the genus.

C. insularum can be distinguished from *C. intermedius* and *C. incisus* in having—

1. No median furrow on the frontal region of the carapace. (Faint furrows are present in *C. intermedius* and *C. incisus*).

2. Anterolateral notches less distinct than those figured for *C. intermedius* (Sakai, 1939, pl. 75, fig. 3 ; 1965, pl. 94, fig. 4) or for *C. incisus* (Shen, 1940, fig. 10).

3. Chela not granular on dorsal border, dentition of male greatly reduced or absent.

4. Walking legs naked except for very interrupted rows of felting on the dactyli. Merus not granular on its anterior border.

5. Dactyli sub-cylindrical rather than compressed. That of the last leg is very short (length twice breadth).

6. Terminal segment of male abdomen paraboloid, not square cut as shown in Shen's figure (1940, fig. 11) of *C. incisus*.

Genus **PARAGRAPSUS** H. Milne Edwards

Paragrapsus Milne Edwards, H., 1853, p. 195. (Type species: *Cyclograpsus quadridentatus* H. Milne Edwards, 1837, by subsequent designation of Tesch, 1918).

Diagnosis

Carapace.—Little vaulted, and not deep (depth up to 0·6 times length). Not smooth as in *Cyclograpsus* but regions not always well defined. Epigastric lobes distinct.

Front.—Not convexly deflexed as in *Cyclograpsus*, but concave, with forwardly projecting frontal margin overhanging first antennae. Frontal width slightly more than half fronto-orbital width. Lateral margins of front not passing imperceptibly into very oblique inner borders of orbits.

Anterolateral Borders.—With one or two distinct teeth behind external orbital angle.

Pterygostome.—With distinct granules and short hairs, but not in orderly arrangement.

Epistome.—Not projecting beyond front in dorsal view.

Antenna 2.—Not excluded from orbital hiatus.

Chelipeds.—Subequal, moderate to large and swollen in adult males. Smaller in females.

Ambulatory Legs.—Sturdy. Meri moderately broad, flattened.

Abdomen.—Seven segmented. In males not occupying whole breadth of sternum between last legs; third segment not greatly expanded laterally. Ultimate segment in mature females approximately twice as broad as long, not deeply impacted in penultimate segment.

Distribution

Wholly restricted to Australia, including Tasmania. Miers' (1876) record of *P. laevis* from New Zealand is certainly erroneous (Hutton, 1882; Chilton and Bennett, 1929), and the poorly known *Paragrapsus urvillei* H. Milne Edwards from Vanikoro Is., Santa Cruz, has been referred by Tesch (1918) to *Helice*.

Discussion

In the past this genus has sometimes been confused with *Chasmagnathus*. Tesch (1918) pointed out its true affinities with *Cyclograpsus*, yet still wrongly transferred *P. gaimardii* to *Helice*. The list of characters in the key to genera (couplet 2 (1)) indicates the distinct division between *Paragrapsus* and *Cyclograpsus* on the one hand, and *Helice* and *Chasmagnathus* on the other.

Within the genus the resemblance between *P. gaimardii* and *P. laevis* is very much closer, both morphologically and ecologically, than that between either of those two species and *P. quadridentatus*.

Key to the Indo–West Pacific Species of the genus Paragrapsus

1. Anterolateral margins with 2 teeth behind the external orbital angle..... 2

   Anterolateral margins with 1 tooth behind the external orbital angle..... .....*P. quadridentatus* (H. Milne Edwards, 1837).

2 (1). First walking legs with felt on anterior surface of carpus and propodus, and on dactyl ; suture between first and second sternites not marked by prominent ridge..... .....*P. laevis* (Dana, 1852).

   First leg of male with felt only on edge of propodus and on dactyl (possibly naked in female) ; first and second sternites of male separated by a distinct ridge..... .....*P. gaimardii* (H. Milne Edwards, 1837).

PARAGRAPSUS QUADRIDENTATUS (H. Milne Edwards)

(Text-figs. 8A, 10A ; pl. 22, fig. 1 ; pl. 23, fig. 9)

Cyclograpsus quadridentatus Milne Edwards, H., 1837, p. 79. Hess, 1865, p. 152.

Paragrapsus quadridentatus (H. Milne Edwards). Milne Edwards, H., 1853, p. 195. Haswell. 1882b, p. 105, pl. 3, fig. 1. de Man, 1889, p. 441. Tesch, 1918, p. 125 (key and footnote). Tweedie, 1942, pp. 21–2, fig. 7.

Chasmagnathus quadridentatus (H. Milne Edwards). Ortmann, 1894a, p. 728.

Material Examined

47 males (6–32 mm), 40 females (6–20 mm).

Victoria : Lady B., Port Phillip. Bass Strait : King I. Tasmania : Wynyard, Ulverstone, North Cape, Cape Portland, Pirates B., Fort Direction, Pittwater, Derwent R. (Bellerive, Sandy B.), Kingston, Howden, Gordon, Adventure B. (Bruny I.), Broadbent.

Material Illustrated

Male, 32 mm, Port Phillip, M. Ward, Jan. 1926. Aust. Mus. P.8598.

Description

Carapace.—Broader than long (*c.* 1·2 times).

Surface microscopically granular on anterolateral areas. Margins of carapace indistinctly beaded. Posterolateral corners deflexed, cardiac and branchial regions not transversely convex.

Cardiac and intestinal regions vaguely defined. Gastrocardiac groove obvious. Epigastric lobes distinct, but not prominent. Gastric regions not defined.

Lateral borders with one large, rounded, projecting tooth behind each external orbital angle. Posterior to this the margins are straight, convergent.

Front projecting, divided by a broad shallow emargination into two broad lobes with anterior margins straight but inclined posteriorly.

Sub-orbital ridge bears some 25 low serrate granules largest beneath base of eye and gradually decreasing in size laterally.

Chelipeds.—Carpus bears no spine on its inner, upper angle.

Chela in larger males longer than high (*c.* 1·2 times), externally punctate (not granular). Inner surface with a longitudinal row of some five large granules and *c.* 8 scattered smaller granules. Fingers with low dentition; tips with horny U-shaped ridge; gape moderately large; large fleshy cushion between fingers proximally.

Female with longitudinal row of granules on outer surface of chela.

Ambulatory Legs.—Reasonably strong, second legs *c.* 1·5 times carapace breadth. Upper border of merus sharp, with blunt spine near distal end.

Dactyl with 6 grooves. Legs naked except for felt in the two upper grooves on dactyl of first leg and some sparse felting on anterior surface of propodus of first leg, in the three upper grooves on dactyl of last leg, and a small patch on upper extremity of propodus of last leg.

Male Sternum.—Suture between first and second segments smooth, not as described for *P. gaimardii*.

Male Abdomen.—Subtriangular. Penultimate segment almost twice as broad as long, twice as broad as ultimate segment. Ultimate segment as broad as long, paraboloid.

Colour.—Dorsal surface of carapace greenish grey or pale brown, legs similar but tinged with pink or purple. Carapace spotted dorsally with irregular, very dark red spots sparsely distributed, at least posteriorly, with more numerous microscopic spots scattered among them. Legs and dorsal surfaces of chelae possessing only the scattered microscopic spots. Under surfaces pale cream.

Habitat

On sandy or shingle beaches or rocky coasts under stones in the lower mid-littoral. In many localities, at least in Tasmania, this species occupies a zone immediately below *Cyclograpus granulosus*, both species prefering semi-exposed to fully-exposed coasts although present in some sheltered localities. On slightly muddy beaches *P. quadridentatus* is sometimes found together with *P. gaimardii*.

Distribution

Tasmania and Victoria.

PARAGRAPSUS LAEVIS (Dana)

(Text-figs. 8B, 10C ; pl. 22, fig. 2 ; pl. 23, fig. 10)

Chasmagnathus laevis Dana, 1852a, p. 252 ; 1852b, p. 365, pl. 23, fig. 7. Kingsley, 1880, p. 222. Haswell, 1882b, p. 106. Miers, 1884, p. 246. Ortmann, 1894a, p. 728. Fulton and Grant, 1906, p. 19.

Paragrapsus Verreauxi Milne Edwards, H., 1853, p. 195. Haswell, 1882b, p. 105.

Paragrapsus laevis (Dana). Heller, 1865, p. 55. Tesch, 1918, p. 125 (key and footnote).

Material Examined

31 males (10–42 mm), 13 females (7·5–32 mm).

Queensland : Brisbane R., Nerang R., Burleigh, Currumbin Ck. New South Wales : Trial B., Port Macquarie, Wallis Lake, Port Stephens, Tuggerah Lakes, Brisbane Water, Broken B., Lane Cove, Port Jackson, Botany B., Jervis B. Victoria : S.E. Victoria, Port Phillip. Tasmania : Tasmania.

Material Illustrated

Male, 26 mm, Port Stephens, Qd Mus. W.1949.

Description

Carapace.— Broader than long (1·15 to 1·25 times). Breadth between external orbital angles slightly less than carapace length (0·95 to 1·0 times).

Surface microscopically granular or punctate. Margins of carapace distinctly beaded. Posterolateral corners rather abruptly deflexed, cardiac and branchial regions not transversely convex.

Cardiac and intestinal regions well defined by wrinkled grooves in most older specimens, but poorly defined in specimens of less than 25 mm. Gastro-cardiac groove distinct. Epigastric lobes prominent, anterior and lateral edges of protogastric region slightly raised above sunken hepatic area. Mesogastric region not well defined.

Lateral borders convex, subparallel, with two deep notches forming two distinct anterolateral teeth behind each external orbital angle.

Front divided into two broad projecting lobes well separated by the median groove.

Sub-orbital ridge bearing some 25 (23 to 26) large, distinct tubercles which are largest beneath base of eye and gradually decrease in size laterally.

Chelipeds.—Carpus bears a more or less blunt spine on its inner upper angle.

Chela in larger males (over *c.* 20 mm) longer than high (*c.* 1·2 times), externally microscopically granular. Granulation on inner surface varying greatly with age. In males of more than 25 mm carapace width raised swelling covered with numerous distinct granules increasing in size towards peak of swelling and tending to form a longitudinal ridge. In smaller males granules much less numerous and less distinct. Fingers with low dentition, tips with horny U-shaped ridge. Gape varying with size, greatest ($\frac{1}{4}$ height of chela) in males over 40 mm.

Females with no distinct granules on inner surface of hand, dentition of fingers lower, almost obsolete, and horny ridges on tips extending much further back (*c.* one-third length of fingers). A row of low granules running along lower part of outer surface and on to immovable finger.

Ambulatory Legs.—Reasonably strong, second legs *c.* 1·5 times carapace breadth. Merus granulate on upper border, with acute spine, lowest and least acute in the last legs, near distal end.

First leg bearing patches of dark felt on distal half of anterior surface of carpus, and on whole of anterior surface of propodus (except for a longitudinal bare strip in the distal quarter). Dactyl with six rows of felt, upper three densest, posterior one thinnest.

Second and third legs with carpus naked, propodus naked or with small patch or stripe of felt on distal half of upper border, dactyl with six rows of felt less dense than on first dactyl.

Last leg usually with carpus naked (rarely with small patch of felt on upper border), upper border of propodus with stripe of felt along distal two-thirds, lower border with stripe on distal half. Dactyl with three upper rows more or less coalesced to form a broad stripe, lower rows faint.

Male Sternum.—Suture between first and second sternites smooth, not as described for *P. gaimardii*.

Male Abdomen.—Subtriangular. Penultimate segment *c.* 1·5 times as broad as long, twice as broad as ultimate segment. Ultimate segment as broad as long, paraboloid.

Colour.—Carapace and legs covered dorsally with small dark red spots which run together but leave irregular bare spots. These bare spots are most common posteriorly on the carapace, and on the legs. Anteriorly the red spots are much denser, usually running together completely to form a solid red area with few pale spots. Wrist and chelae red dorsally, fading to cream ventrally.

Habitat

Under stones or in burrows about mean sea level. Not penetrating far up estuaries.

Distribution

Eastern Australia, as far south as Tasmania and north to Moreton Bay. The Tasmanian record depends on a single specimen (Aust. Mus., old coll., P.7418). Haswell's record from Port Molle is much further north than personal collecting would suggest was the range of this species.

Miers' (1876) record of this species from New Zealand was queried by Hutton (1882), and has not since been confirmed.

Discussion

One specimen (P.7273, male 42 mm) (see figs. 9B, 10D ; pl. 22, fig. 4 ; pl. 23, fig. 12) at the Australian Museum is unusual in that it seems half-way between *P. gaimardii* and *P. laevis* in the following characters.

1. The ratio of fronto-orbital width to length of carapace (0·85).

2. The depth of the division between the two frontal lobes.

3. The distinctness of the post-frontal lobes.

4. The granulation of the inner surface of the chela.

5. The shape of the teeth on the suborbital ridge.

6. The felting of the posterior leg.

7. The presence of a low ridge between first and second sternal segments.

8. The vaulting of the cardiac region.

9. The colour is almost completely washed out, but the spots that remain are much larger than those of *P. gaimardii*.

In the felting of the first walking leg the specimen closely resembles *P. laevis*.

The specimen is one of a series of six collected by M. Ward under stones on sandy mud flat at Port Phillip, Victoria. The other specimens in the series are definitely *P. laevis*. That such a large number of characters should be intermediate between those of two distinct species (placed in different genera by Tesch, 1918) is remarkable. The crab shows no features peculiar to itself that are not intermediate between *P. laevis* and *P. gaimardii* and the possibility that this specimen is a hybrid can not be ignored. It was collected from a locality where the ranges of both species overlap.

PARAGRAPSUS GAIMARDII (H. Milne Edwards)

(Text-figs. 9A, 10B ; pl. 22, fig. 3 ; pl. 23, fig. 11)

Cyclograpsus Gaimardii Milne Edwards, H., 1837, p. 79.

Paragrapsus Gaimardii (H. Milne Edwards). Milne Edwards, H., 1853, p. 196. Haswell, 1882b, p. 105, pl. 2, fig. 4.

Paragrapsus gaimardii (H. Milne Edwards). Hale, 1927a, pp. 179–80, fig. 180. Tweedie, 1942, p. 20, fig. 6.

Helice gaimardii (H. Milne Edwards). Tesch, 1918, p. 119 (key and footnote).

Material Examined

85 males (5–48 mm), 60 females (15–47 mm).

Victoria : Port Phillip, Queenscliffe. South Australia : Coorong. Tasmania : Wynyard, Emu B., Swan B. (Tamar R.), Triabunna, Carlton R., Dunally, Eaglehawk B., Pipe Clay Lagoon, Ralph's B., Pittwater, Derwent R. (Sandy B.), Brown's R., Howden, Oyster Cove, Isthmus B. (Bruny I.), Southport, Strahan.

Material Illustrated

Male, 41 mm, Port Phillip, M. Ward, Aug. 1924. Aust. Mus. P.7259.

Description

Carapace.—Subquadrate slightly broader than long (1·05 to 1·15 times). Breadth between external orbital angles markedly less than carapace length (0·75 to 0·85 times).

Surface microscopically granular, margins of carapace distinctly beaded. Posterolateral corners deflexed but curvature merges smoothly with transversely convex cardiac and branchial regions. Regions not well defined although mesogastric, cardiac and intestinal areas usually distinguishable. Epigastric lobes less prominent than in *P. laevis*, but distinct.

Lateral borders slightly divergent posteriorly, with 2 distinct teeth behind each external orbital angle.

Entire front markedly projecting and shelf-like, incompletely divided into 2 lobes by a shallow median emargination.

Sub-orbital ridge bearing some 25 (23–26) serrate teeth largest beneath base of eye and gradually decreasing in size laterally.

Chelipeds.—Carpus bearing a more or less blunt granular spine on its inner upper angle.

Chela in larger males longer than high (*c.* 1·2 times), externally microscopically granular, with longitudinal row of granules extending to base of immovable finger. Most of inner surface bearing small scattered granules tending to form a longitudinal row of some 10 granules. Fingers with low dentition, tips with horny U-shaped ridge, gape slight, even in large males.

Female, with row of granules on outer surface of hand more distinct and extending to tip of immovable finger ; only a very faint row of granules on inner surface ; horny ridge on tips of fingers extending much further back (*c.* one-third length of fingers).

Ambulatory Legs.—Strong, second legs *c.* 1·5 times carapace width. Merus granulate on upper border, with spine, lowest and least acute on the last legs, near distal end.

First leg of male bearing strip of dark felt along distal half of ventral border of propodus ; dactyl naked. First leg of female usually naked.

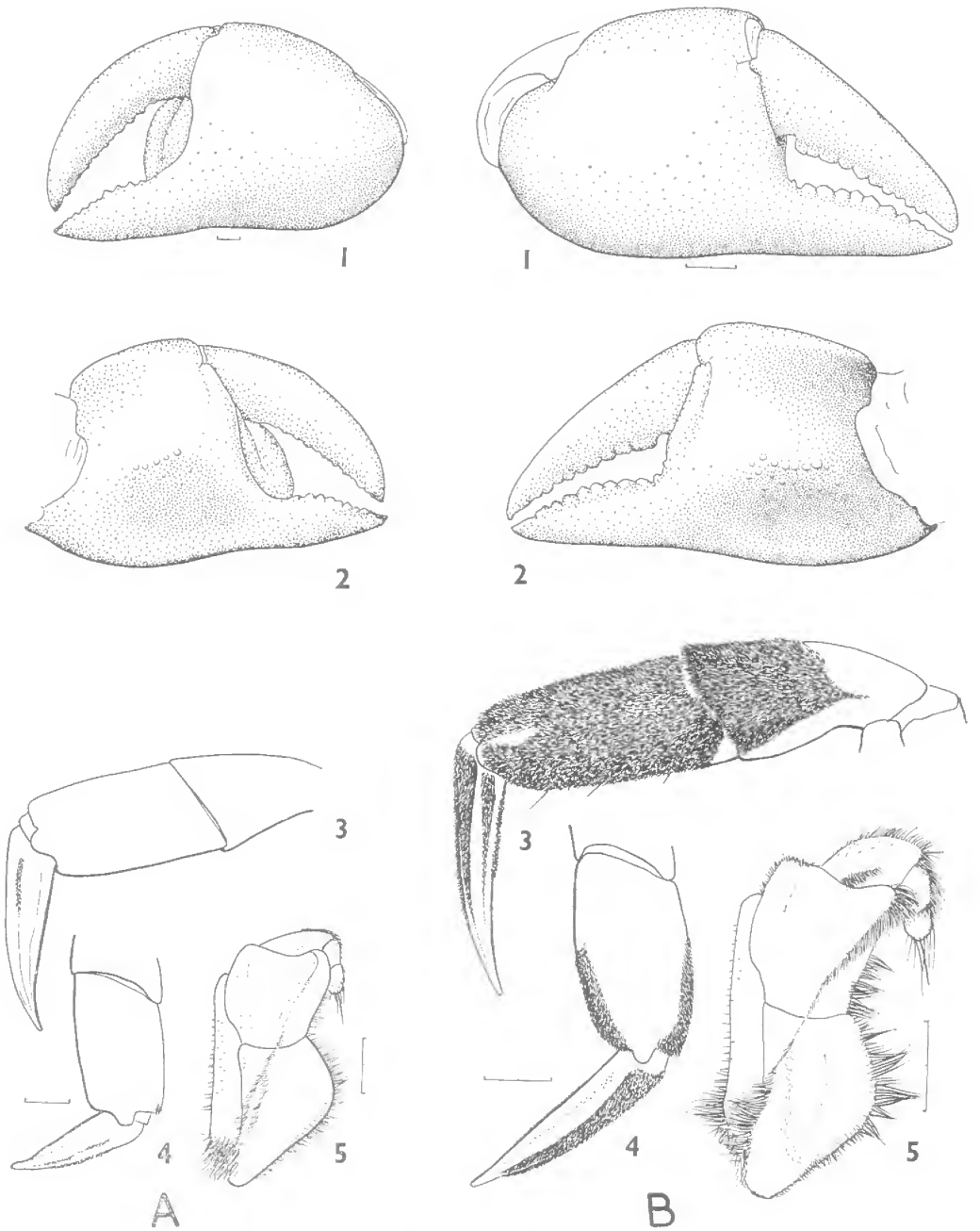
Second and third legs of both sexes naked.

Last leg of both sexes with 2 rows of felt on anterior (upper) edge of dactyl. Ventral border of propodus usually with a small patch at its distal end ; this patch is often larger and more commonly found in Victorian specimens than in Tasmanian ones.

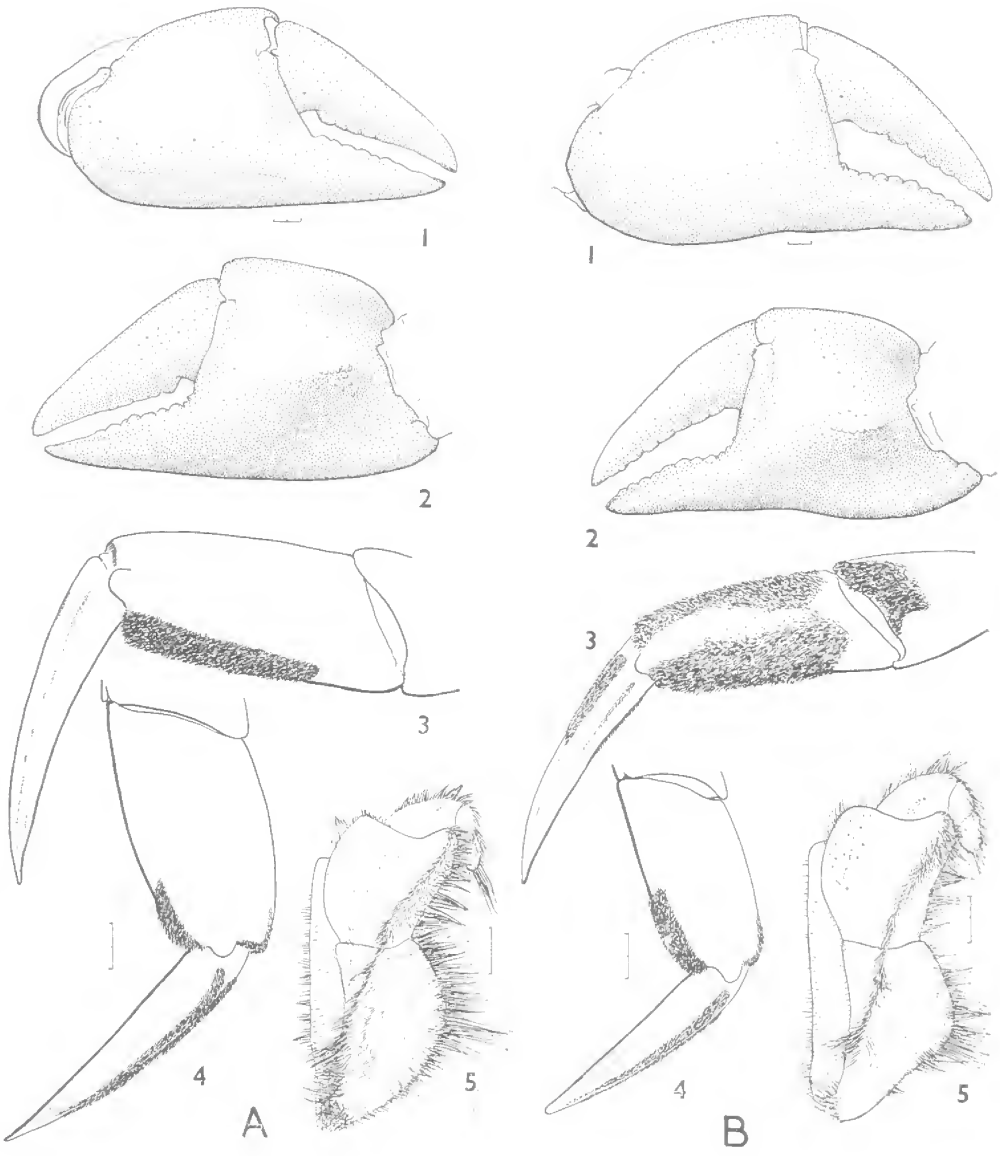
Male Sternum.—Suture between first and second sternites usually with edge of first sternite more or less distinctly raised above second.

Male Abdomen.—Broad. Penultimate segment more than twice as broad as long, twice as broad as ultimate segment. Ultimate segment broader than long, sub-triangular, with rounded tip.

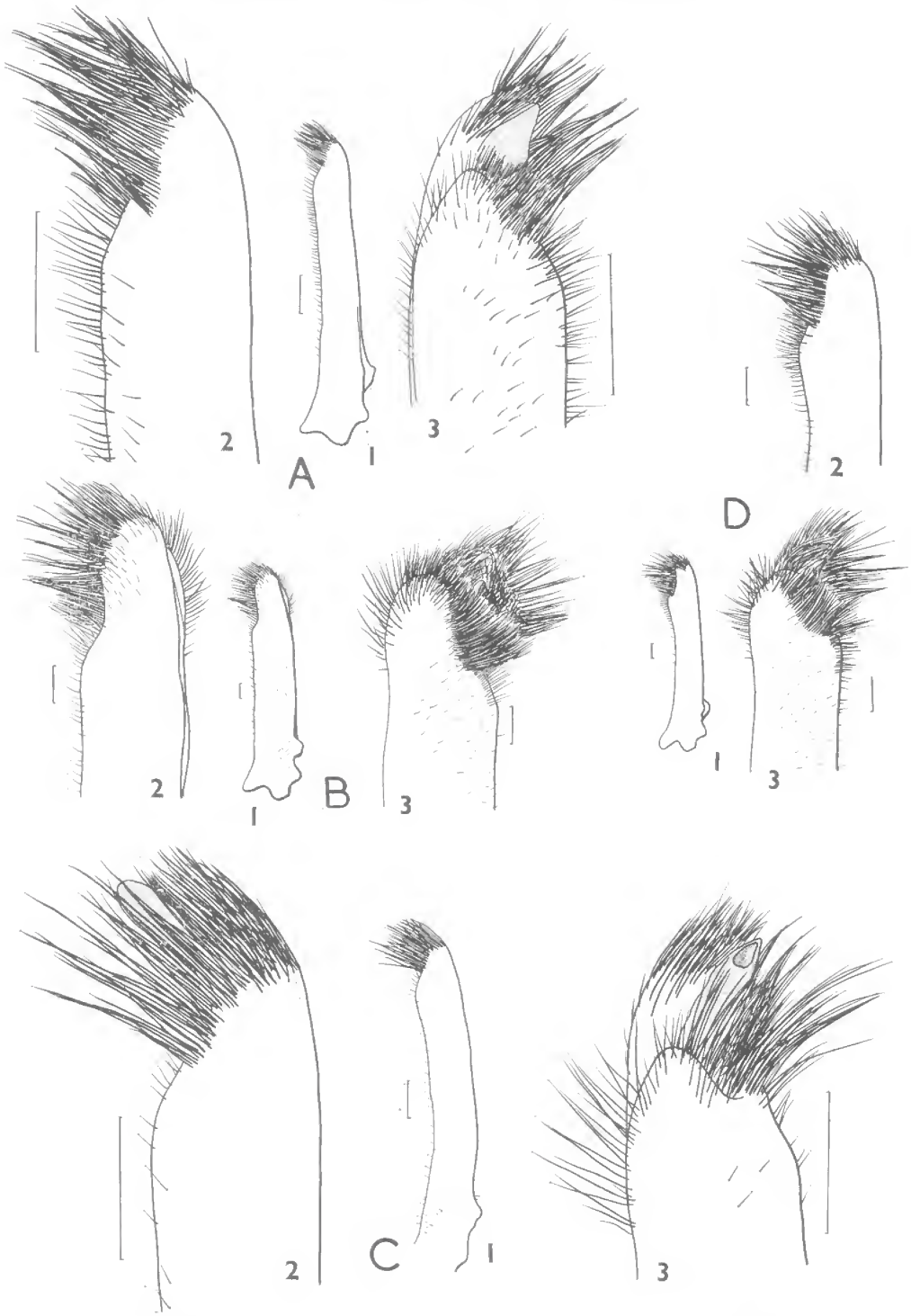
Colour.—Dorsal surface of carapace yellowish brown with dark red spots on all surfaces visible in dorsal view. On anterior half of carapace spots are smaller but more tightly packed, sometimes running together to form large blotches. Spots anteriorly on ventral surface of carapace (rarely extending to tip of abdomen), and on anterior faces of ambulatory legs covering all surfaces of the distal three segments. Ventral surfaces otherwise grey. Outer surface of chelae orange, especially dorsally.



Text-figure 8.—A, *Paragrapsus quadridentatus*; B, *P. laevis*. 1, Chela, outer face; 2, Chela, inner face; 3, Right first walking leg, anterior face; 4, Right last walking leg, posterior face; 5, Third maxilliped. Scale lines 2 mm.



Text-figure 9.—A, *Paragrapsus gaimardii*; B, *P. gaimardii/P. laevis* intermediate. 1, Chela, outer face; 2, Chela, inner face; 3, Right first leg, anterior face; 4, Right last leg, posterior face; 5, Third maxilliped. Scale lines 2 mm.



Text-figure 10.—Right first male pleopods of A, *P. quadridentatus*; B, *P. gaimardii*; C, *P. laevis*; D, *P. gaimardii*/*P. laevis* intermediate. 1, Whole pleopod, abdominal surface; 2, Tip, abdominal surface; 3, Tip, sternal surface. Scale lines 1 mm.

HABITAT

Under stones or in burrows on sheltered sandy or slightly muddy shores, most commonly in lower intertidal areas extending well into the sublittoral, but sometimes found above high tide in burrows. Tweedie (1942) states that this species is never found with "*C. audouinii*" (= *C. granulosus* of present paper). This is only partly true. In Tasmania, both species are sometimes found on the same strip of coast, especially on sheltered shingly or pebbly beaches. However, *C. granulosus* generally occupies a higher zone on the shore than does *P. gaimardii*, and moreover *P. gaimardii* is a more estuarine species than either *P. quadridentatus* or *C. granulosus*, even extending short distances up streams and rivers.

DISTRIBUTION

Victoria, South Australia, all sheltered coasts of Tasmania (Tweedie, 1942; Guiler, 1956).

Snelling's (1959) record of this species from the Brisbane R. was due to a misidentification of specimens of *P. laevis*.

DISCUSSION

Tesch (1918, p. 125) considered this species to belong to the genus *Helice*. By virtue of its possession of all the characters of *Paragrapsus* in couplet 2 (1) of the key to genera there is no doubt that it should remain in the present genus. If further confirmation is needed it is provided by the existence of a specimen intermediate between *P. gaimardii* and *P. laevis* (see above).

DISCUSSION

Although it is convenient to postpone a more detailed zoogeographical discussion until the taxonomy of the Australian species of the genus *Sesarma* has been completed, the high proportion of endemism is worthy of some comment. Of the four genera here treated, two (*Helograpsus* and *Paragrapsus*) are wholly confined to Australia. Of the seven species which occur on the Australian continent (including Tasmania), only two are to be found elsewhere (*Cyclograpsus audouinii* in New Guinea, *Helice leachii* throughout the Indo–West Pacific).

Also, of these seven species all but *H. leachii* occur in the south, and three (*Cyclograpsus granulosus*, *Paragrapsus quadridentatus*, *P. gaimardii*) do not range further north than the Victorian and South Australian coasts. In contrast to this, the genus *Sesarma* in Australia shows an essentially northern distribution, with only two species extending south for any distance down the New South Wales coast.

It seems no coincidence that of the species so far discussed, *H. leachii*, in addition to having a *Sesarma*-like distribution, should also have the best developed, almost *Sesarma*-like reticulation of hairs on the pterygostome (see p. 127). It would appear that this reticulation has considerable adaptive value for estuarine, tropical, semi-terrestrial crabs, and is a major factor determining the geographical distribution of this subfamily on the Australian continent.

ACKNOWLEDGEMENTS

We are very grateful to the Directors and Curators in the following Museums in Australia and New Zealand who have allowed us to examine crustacean material in their care: Australian Museum, Sydney (Dr. J. W. Evans, Mr. F. A. McNeill, and later Dr. J. C. Yaldwyn); Queensland Museum, Brisbane (Mr. G. Mack, and later Mr. J. T. Woods); National Museum of Victoria, Melbourne (Mr. J. McNally); Tasmanian Museum, Hobart (Dr. W. Bryden, Mrs. J. Greenhill); South Australian Museum, Adelaide (Mr. T. D. Scott); Western Australian Museum, Perth (Dr. W. D. L. Ride, Dr. R. W. George); Dominion Museum, Wellington (Dr. R. A. Falla, Dr. R. K. Dell); and Canterbury Museum, Christchurch (Mr. E. G. Turbott). Similar thanks are due to Dr. J. R. Grindley of the South African Museum, Cape Town, for sending material of *Cyclograpsus punctatus*. We also wish to thank Dr. J. Forest, Muséum National d'Histoire Naturelle, Paris, for so kindly sending us photographs of type material in his care.

Especial thanks are due to Prof. W. Stephenson, Mr. F. A. McNeill, Dr. J. C. Yaldwyn and Dr. R. W. George for most helpful discussion and encouragement, and to Mr. K. Hudson, (University of Queensland) and Mr. A. Beswick (University of Tasmania) for photographic illustrations. The expenses of the work were covered by the Commonwealth Research Grants to the University of Queensland and to the University of Tasmania.

LITERATURE CITED

Balss, H., 1935. Brachyura of the Hamburg Museum expedition to south-western Australia, 1905. *J. roy. Soc. W. Aust.*, 21, pp. 113–51, 13 figs.

Barnard, K. H., 1950. Descriptive catalogue of South African decapod Crustacea (crabs and shrimps). *Ann. S. Afr. Mus.*, 38, pp. 1–837, 154 figs.

Bennett, E. W., 1964. The marine fauna of New Zealand: Crustacea Brachyura. *N.Z. Dep. sci. industr. Res. Bull.*, 153, pp. 1–120, 141 figs.

Bennett, Isobel, and Pope, Elizabeth C., 1953. Intertidal zonation of the exposed rocky shores of Victoria, together with a rearrangement of the biogeographical provinces of temperate Australian shores. *Aust. J. Mar. Freshw. Res.*, 4, pp. 105–59, 5 figs., 6 pls.

Chilton, C., 1911. The Crustacea of the Kermadec Islands. *Trans. N.Z. Inst.*, 43, pp. 544–73.

Chilton, C., and Bennett, E. W., 1929. Contributions for a revision of the Crustacea Brachyura of New Zealand. *Trans. N.Z. Inst.*, 59, pp. 731–78.

Crosnier, A., 1965. Crustacés décapodes Grapsidae et Ocypodidae. *Faune de Madagascar*, 18, pp. 1–143, pls. 1–11.

Dana, J. D., 1852a. Conspectus Crustaceorum quae in Orbis Terrarum circumnavigatione, Carlo Wilkes e Classe Republicae Federatae Duce, lexit et descripsit. *Proc. Acad. nat. Sci. Philad.*, 5, pp. 247–54.

———————, 1852b. Crustacea. *In* U.S. Exploring Expedition during the Years 1838–1842 under the Command of Charles Wilkes, U.S.N. Vol. 13, pp. 267–90, atlas, 96 pls. (Philadelphia).

Edmondson, C. H., 1925. Marine zoology of the tropical central Pacific. Crustacea. *Bull. Bishop Mus., Honolulu*, 27, pp. 3–62, figs. 1–8, pls. i–iv.

———————, 1959. Hawaiian Grapsidae. *Occ. Pap. Bishop Mus.*, 22, pp. 153–202, 27 text-figs.

Filhol, H., 1886. Catalogue des Crustacés de la Nouvelle–Zélande, des îles Auckland et Campbell. *In* Mission de l'Ile Campbell, Vol. 3, pt. 2, pp. 349–510, pls. 38–55. (Paris).

Forest, J., and Guinot, Danièle, 1961. Crustacés Décapodes Brachyoures de Tahiti et des Tuamotu. *In* Expédition française sur les récifs coralliens de la Nouvelle–Calédonie. Volume préliminaire, pp. i–xi, 1–195, text-figs. 1–178, 18 pls., 7 maps.

———————, 1962. Remarques biogeographiques sur les crabes des Archipels de la Société et des Tuamotu. *Cah. Pacif.*, 4, pp. 41–75, 2 tables, 1 fig.

Fulton, S. W., and Grant, F. E., 1906. Census of the Victorian decapod Crustacea. Part I. (Brachyura). *Proc. roy. Soc. Vict.*, 19, pp. 16–20.

Garth, J. S., 1957. Reports of the Lund University Chile Expedition 1948–49. 29. The Crustacea Decapoda Brachyura of Chile. *Lunds Univ. Arssk.*, (2) 53 (7), pp. 1–127, pls. I–IV.

———————, 1958. Brachyura of the Pacific coast of America: Oxyrhyncha. *Allan Hancock Pacif. Exped.*, 21, pp. 1–838, pls. $A–Z_4$, 1–55.

Guiler, E. R., 1952. A list of the Crustacea of Tasmania. *Rec. Q. Vict. Mus.*, 3, pp. 15–44.

———————, 1956. Supplement to a list of the Crustacea of Tasmania. *Rec. Q. Vict. Mus.*, n.s., 5, pp. 1–8.

Haan, W. de, 1833–49. Crustacea. *In* P.F. von Siebold, Fauna Japonica. (J. Müller & Sons: Amsterdam).

Hale, H. M., 1924. The flora and fauna of Nuyts Archipelago and the Investigator Group. No. 16—The Crustacea. *Trans. roy. Soc. S. Aust.*, 48, pp. 67–73, pls. 4, 5.

———————, 1927a. The Crustaceans of South Australia. Part I. (Govt. Printer: Adelaide).

———————, 1927b. The fauna of Kangaroo Island. I. The Crustacea. *Trans. roy. Soc. S. Aust.*, 51, pp. 307–21, figs. 1–7.

Haswell, W. A., 1882a. On some new Australian Brachyura. *Proc. Linn. Soc. N.S.W.*, 6, pp. 540–51.

———————, 1882b. Catalogue of the Australian Stalk- and Sessile-eyed Crustacea. (Australian Museum: Sydney).

Heller, C., 1862. Vorläufiger Bericht über die wahrend der Weltumseglung der K. Fregatte Novara gesammelten Crustaceen. *Verh. zool.-bot. Ges. Wien*, 12, pp. 519–523.

———————, 1865. Crustaceen. *In* Reise der Novara um die Erde. Zool. Vol. 2, part 3, pp. 1–280, pls. 1–25. (Vienna).

Hess, W., 1865. Beiträge zur Kenntniss der Decapoden-Krebse Ost-Australiens. *Arch. Naturgesch.*, 31, pp. 127–173, figs. 6, 7.

Hutton, F. W., 1882. The stalk-eyed Crustacea of New Zealand. *N.Z. J. Sci. Tech.*, 1 (6). pp. 263–4.

Jacquinot, H., and Lucas, H., 1853. Crustacés. *In* Voyage au Pôle Sud et dans l'Océanie sur les corvettes l'Astrolabe et la Zélée executé pendent 1837–40, sous le commandement de M. J. Dumont d'Urville. Zoologie, vol. 3, pp. 1–107 ; atlas, Crustacea, pls. 1–9 (1852) (Gide et Baudry : Paris).

Kingsley, J. S., 1880. Carcinological notes, No. IV.—Synopsis of the Grapsidae. *Proc. Acad. nat. Sci. Philad.*, 1880, pp. 187–224.

Krauss, C. F. F., 1843. Die Südafrikanischen Crustaceen eine Zusammenstellung aller bekannten Malacostraca, Bemerkungen über deren Lebensweise und geographische Verbreitung, nebst Beschreibung und Abbildung mehrer neuen Arten. (Stuttgart).

Lenz, H., 1901. Ergebnisse einer Reise nach dem Pacific (Schauinsland 1896–1897). Crustaceen. *Zool. Jb.* (*Syst.*). 14, pp. 429–82, pl. 32.

Macleay, W. S., 1838. On the brachyurous Decapod Crustacea brought from the Cape by Dr. Smith. *In* Smith, A., Illustrations of the zoology of South Africa. Invertebratae, pp. 53–71, pls. 2, 3.

McNeill, F. A., 1920. Studies in Australian carcinology, No. 1. *Rec. Aust. Mus.*, 13, pp. 105–09, pl. 19.

———, 1962. Crabs of the Sydney foreshores. *Aust. nat. Hist.*, 14, pp. 37–43.

Man, J. G. de, 1887. Übersicht der indo-pacifischen Arten der Gattung *Sesarma* Say, nebst einer Kritik der von W. Hess und E. Nauck in den Jahren 1865 und 1880 beschriebenen Decapoden. *Zool. Jb.* (*Syst.*), 2, pp. 639–722, pl. 17.

———, 1889. Ueber einige neue oder seltene indo-pacifische Brachyuren. *Zool. Jb.* (*Syst.*), 4, pp. 409–52, pls. 9–10.

———, 1895–1898. Bericht über die von Herrn Shiffseapitän Storm zu Atjeh an den Westliehen küsten von Malakka, Borneo und Celebes sowie in der Java-See gesammelten Decapoden und Stomatopoden. Zweiter theil. *Zool. Jb.* (*Syst.*), 9, pp. 75–514.

Miers, E. J., 1876. Catalogue of the Stalk- and Sessile-eyed Crustacea of New Zealand. (N.Z. Col. Mus. Geol. Surv.: Wellington).

———, 1884, Crustacea. *In* Report of the Zooloogical Collections made in the Indo Pacific Ocean during the Voyage of H.M.S. *Alert*. 1881–1882. pp. 178–322, 513–75, pls. 18–32, 46–51. (British Museum : London).

———, 1886. Report on the Brachyura, collected by H.M.S. Challenger during the years 1873–76. Rep. Voy. *Challenger*. Zool. Vol. 17, part 2. pp. i–l, 1–362, pls. 1–2g.

Milne Edwards, A., 1873. Recherches sur la faune carcinologique de la Nouvelle-Calédonie. 2^{me} partie. *Nouv. Arch. Mus. Hist. nat., Paris*, 9. pp. 155–332, pls. 4–18.

Milne Edwards, H., 1837. Histoire naturelle des Crustacés, comprenant l'anatomie, la physiologie et la classification de ses animaux. Vol. I. (Lib. Roret : Paris).

———, 1853. Memoire sur la Famille des Ocypodiens. *Ann. Sci. nat. Zool.*, (3) 20, pp. 165–228, pls. 6–11.

Montgomery, S. K., 1931. Report on the Crustacea Brachyura of the Percy Sladen Trust Expedition to the Abrolhos Islands under the leadership of Prof. W. J. Dakin in 1913, along with other crabs from Western Australia. *J. Linn. Soc. Lond. (Zool.)*, 37, pp. 405–64, 1 text-fig., pls. 24–30.

Nobili, G., 1906. Faune carcinologique de la Mer Rouge. Decapodes et Stomatopodes. *Ann. Sci. nat. Zool.*, (9) 4, pp. 1–347, pls. 1–11.

Ortmann, A., 1894a. Die Decapoden Krebse des Strassburger Museum. Teil VIII. *Zool. Jb. (Syst.)*, 7, pp. 683–772, pl. 23.

————, 1894b. Crustaceen. *In* Richard Semon's Zoologische Forschungsreisen in Australien und dem Malayischen Archipel. *Denkschr. med-naturw. Ges. Jena*, 8, pp. 1–80, 13 pls.

Parisi, B., 1918. I Decapodi giapponesi del Museo di Milano. VI. Catometopa e Paguridea. *Atti Soc. ital. Milano*, 57, pp. 90–115, pl. 8.

Rathbun, Mary J., 1907. Reports on the scientific results of the expedition to the tropical Pacific, in charge of A. Agassiz, by the U.S. Fish Commission steamer *Albatross*. IX, X. The Brachyura. *Mem. Mus. comp. Zool. Harv.*, 35 (2), pp. 21–74, 91, 9 pls.

————, 1918. The Grapsoid crabs of America. *Bull. U.S. Nat. Mus.*, 97, pp. 1–461, 161 pls.

Richardson, L. R., 1949. A guide to the brachyrhynchous crabs. *Tuatara*, 2, pp. 29–36, 23 figs.

Sakai, T., 1939. Studies on the Crabs of Japan. IV. Brachygnatha, Brachyrhyncha. pp. 365–741, pls. 42–111. (Yokendo Ltd.: Tokyo).

————, 1965. The Crabs of Sagami Bay collected by His Majesty the Emperor of Japan. pp. i–xvi, 1–206, 1–92, 1–32, pls. 1–100. (Maruzen : Tokyo).

Shen, C. J., 1940. Four new species of Brachyura from China seas. *J. Hong Kong fish. Res. Sta.*, 1 (2), pp. 255–62.

Snelling, Barbara, 1959. The distribution of intertidal crabs in the Brisbane River. *Aust. J. Mar. Freshw. Res.*, 10, pp. 67–83, pls. 1–3.

Stimpson, W., 1907. Report on the Crustacea (Brachyura and Anomura) collected by the North Pacific Exploring Expedition. *Smithson. misc. Coll.*, 49, pp. 1–240, 26 pls.

Tesch, J. J., 1918. The Decapoda Brachyura of the *Siboga* Expedition. I. Hymenosomidae, Retroplumidae, Ocypodidae, Grapsidae and Gecarcinidae. *Siboga* Exped., Monogr. 39*C*, Livre 82, pp. 1–148, pls. 1–6.

Thomson, G. M., 1913. The natural history of Otago Harbour and the adjacent sea, together with a record of the researches carried on at the Portobello marine fish hatchery. Part 1. *Trans. N. Z. Inst.*, 45, pp. 225–51, pl. 10.

Tweedie, M. W. F., 1942. The Grapsid and Ocypodid crabs of Tasmania. *Pap. roy. Soc. Tasm.*, 1941, pp. 13–25.

Verwey, J., 1930. Einiges über die biologie Ost-Indischer mangrovekrabben. *Treubia*, 12 (2), pp. 167–261, pls. 6–14.

Whitelegge, T., 1889. List of the marine and freshwater invertebrate fauna of Port Jackson and the neighbourhood. *J. roy. Soc. N.S.W.*, 23, pp. 163–323.

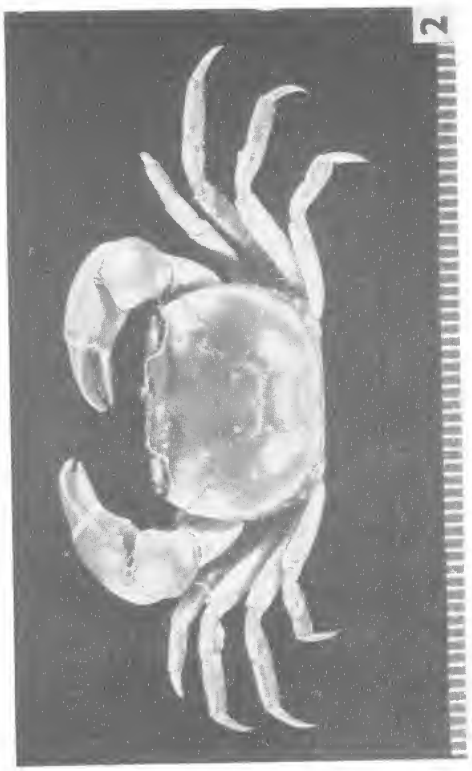
EXPLANATION OF PLATES

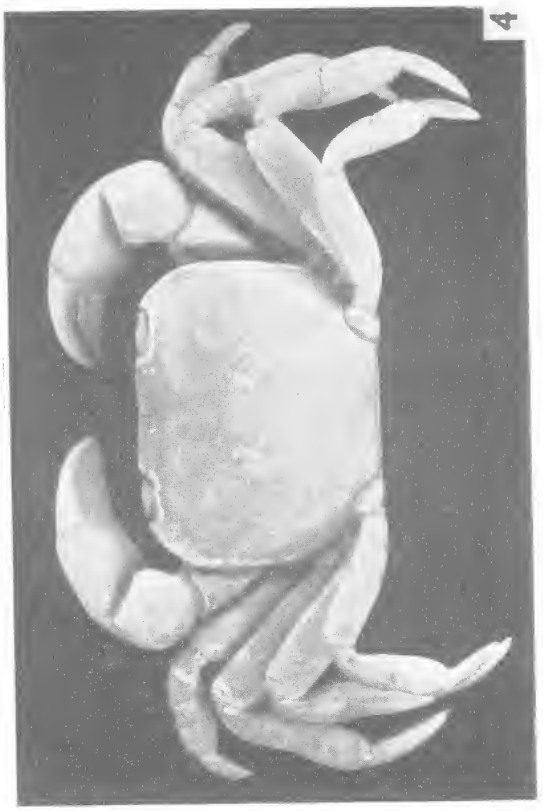
Plate XX. 1, *Helice leachii*; 2, *Helograpsus haswellianus*; 3, *Cyclograpsus punctatus*; 4, *C. lavauxi*. Scale in mm.

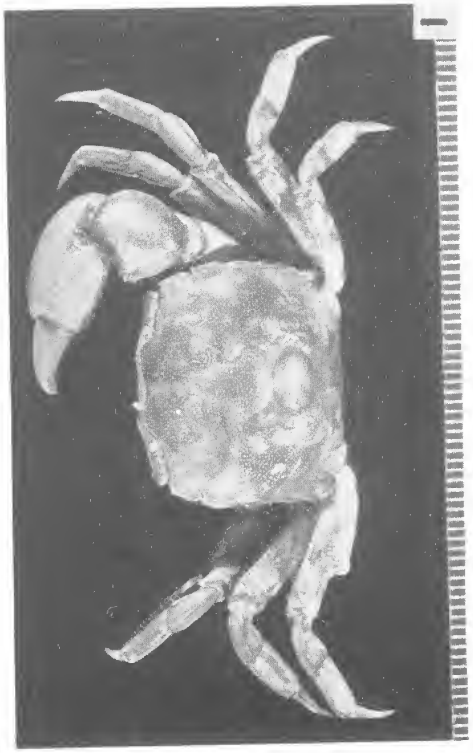
Plate XXI. 1, *Cyclograpsus audouinii* (Queensland); 2, *C. audouinii* (South Australia); 3, *C. granulosus*; 4, *C. insularum*. Scale in mm.

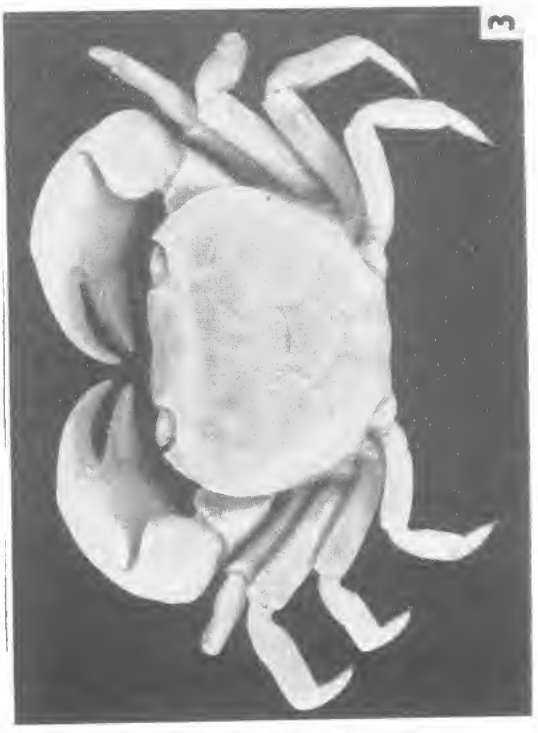
Plate XXII. 1, *Paragrapsus quadridentatus*; 2, *P. laevis*; 3, *P. gaimardii*; 4, *P. gaimardii*, *P. laevis* intermediate. Scale in mm.

Plate XXIII. Male abdomen of 1, *Helice leachii*; 2, *Helograpsus haswellianus*; 3, *Cyclograpsus punctatus*; 4, *C. lavauxi*; 5, *C. audouinii* (Queensland); 6, *C. audouinii* (Western Australia); 7, *C. granulosus*; 8, *C. insularum*; 9, *Paragrapsus quadridentatus*; 10, *P. laevis*; 11, *P. gaimardii*; 12, *P. gaimardii*, *P. laevis* intermediate.

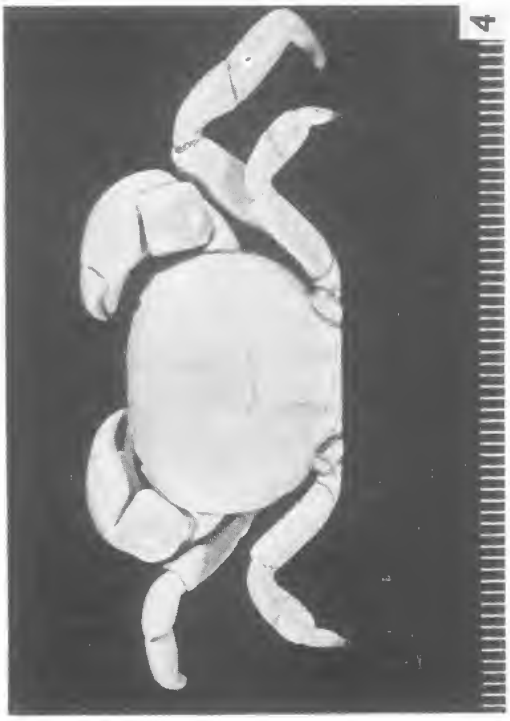

2


4


1

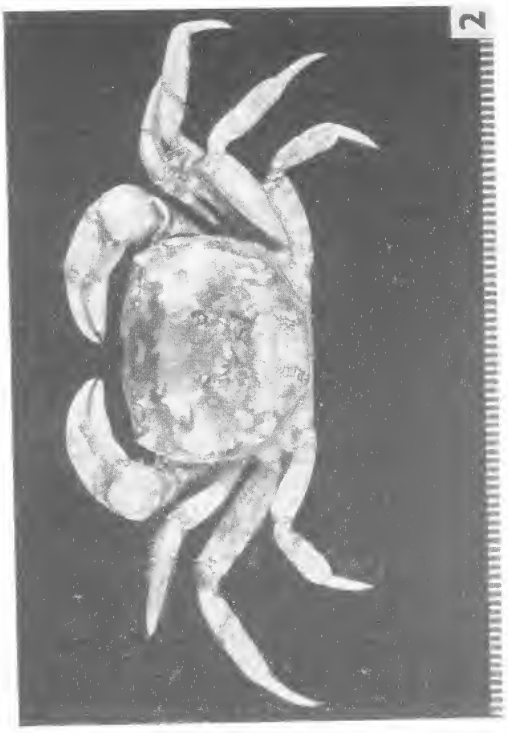

3

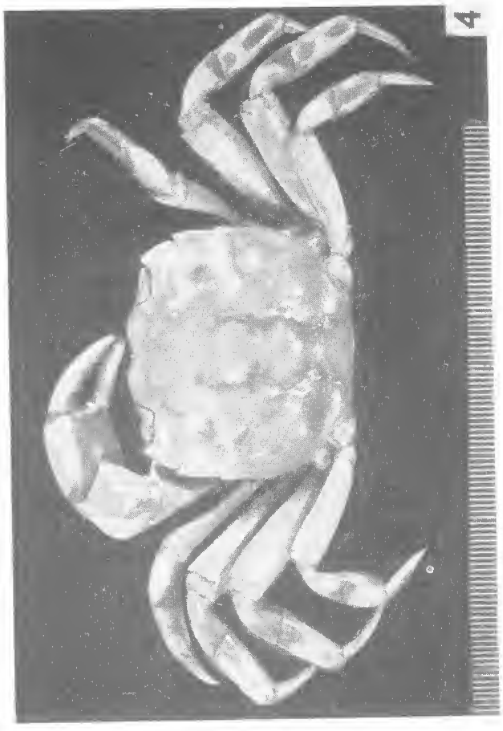

2

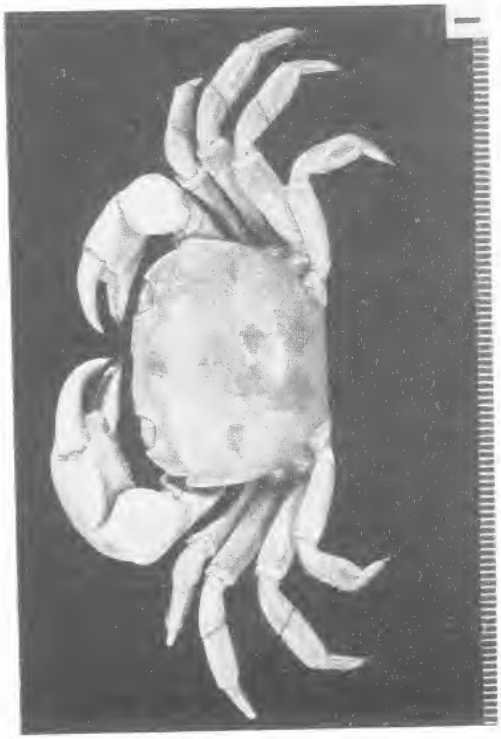

4

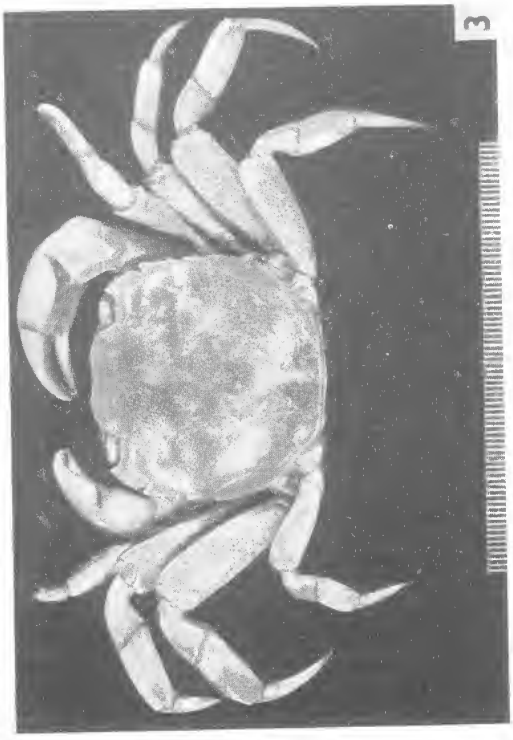

1

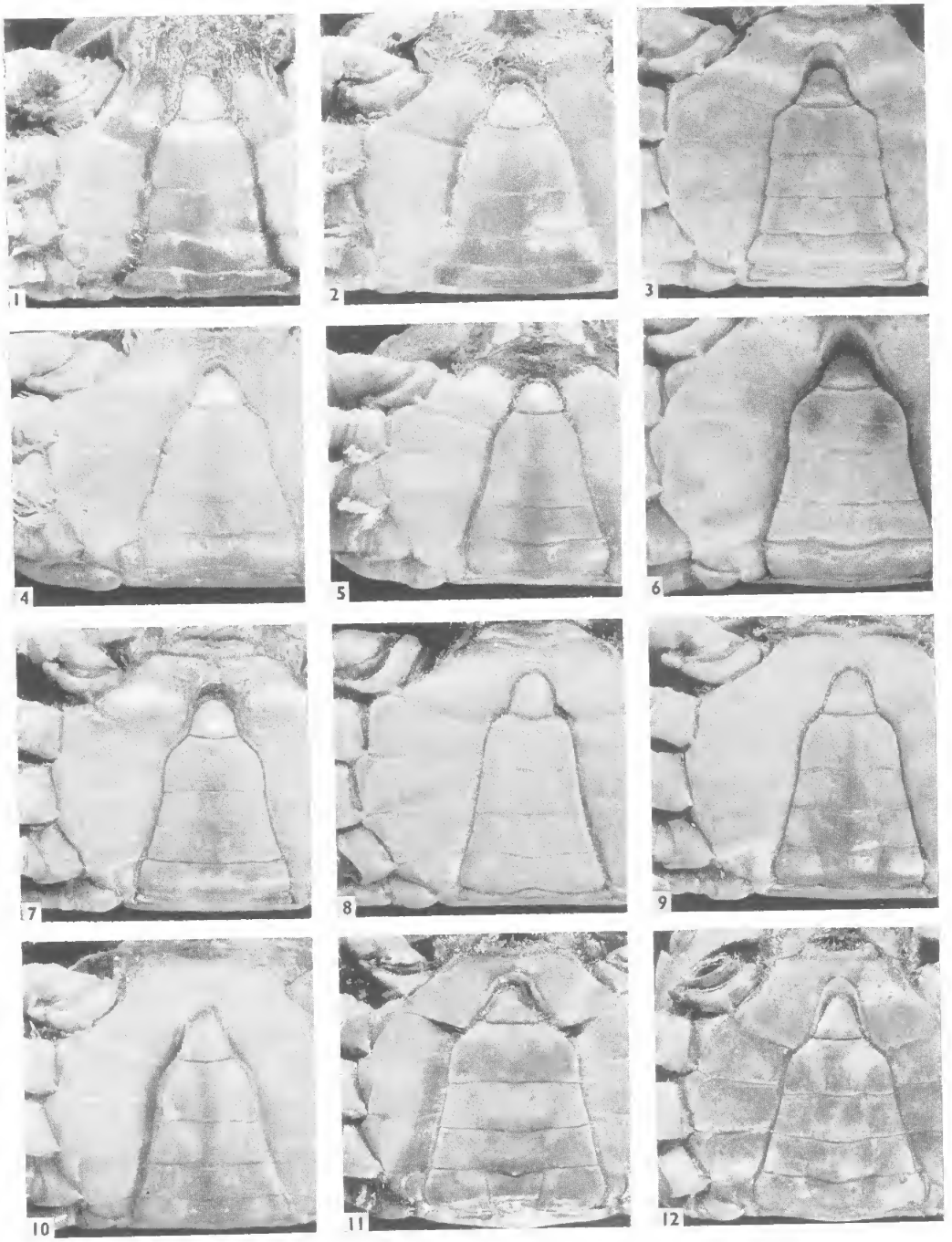

3


2


4


1


3


1
2
3
4
5
6
7
8
9
10
11
12

OBSERVATIONS AND SYSTEMATIC NOTES ON THE RED-CHEEKED PARROT

JOSEPH M. FORSHAW
Division of Wildlife Research, C.S.I.R.O., Canberra

SUMMARY

The Red-cheeked Parrot, *Geoffroyus geoffroyi* (Bechstein), was the subject of limited observations, during November, 1963, at Iron Range, North Queensland, and a brief account of this work is given. These observations have been coupled with a systematic examination of the subspecies described from this region.

The field behaviour observations on the Red-cheeked Parrot, *Geoffroyus geoffroyi* (Bechstein), as given below, were made during November, 1963, by the author, in company with Mr. K. J. Sellick, at Iron Range, North Queensland.

The boundaries of the range of this species in Australia are uncertain, but Thomson (1935) gives the area inhabited as the dense tropical jungles of the Hayes, Lockhart, Nesbit, and Rocky Rivers. Two males were collected by him on the Upper Lockhart River. McLennan (see Macgillivray, 1913) had previously collected specimens on the Pascoe River, while in 1948 Vernon (see Mack, 1953), when collecting for the Queensland Museum, obtained birds on the Peach River and at Iron Range on the Claudie River. The Red-cheeked Parrot appears to be restricted to that area on the east coast of Cape York Peninsula bounded by the Pascoe River in the north and the Rocky River in the south. It does not occur west of the dividing range. Within this restricted and somewhat specialised habitat Thomson (1935) recorded the species as numerous. The author found this to be so at Iron Range.

OBSERVATIONS

HABITAT

A detailed account of the Claudie River district, in which Iron Range is situated, has been given by Forshaw (1964). The particular area in which these observations were made is a reasonably large stand of rain forest bordering the Claudie River at a distance of approximately eight miles in a direct line from the east coast. The road from Iron Range airstrip to the jetty at Portland Roads also passes through the forest alongside the river. The predominant vegetation consists

of *Ficus* trees, many species of lianas such as *Entada scandens*, *Cedrella toona* trees, *Castanospermum australe*, and *Archontophoenix cunninghami*, a type of palm. Because of the dense canopy ground coverage is restricted, but the stinging trees, *Pipturus argenteus* and *Laportea* spp., and the Bird Nest Fern, *Asplenium nidus*, are numerous in certain groves. The fruit or nuts borne by most of these plants are major factors in supporting the abundant avifauna.

Daily Movements

The Red-cheeked Parrots exhibited a definite pattern in their daily movements. Soon after sunrise they would make their way from roosting sites in the tall trees by the river to feeding areas, which seemed to be in the interior of the forest. En route many birds would alight on the very top of a leafless, uppermost branch of a tall tree by the roadside and call loudly for intervals of two minutes or so. The stance shown (text-fig. 1) would be adopted, and the wings vibrated in accompaniment to the call. Only twice were two or more birds seen calling from the top of the same tree, but frequently up to ten birds were calling from neighbouring trees. As far as could be ascertained the parrots selected the trees at random and did not appear to have any definite calling perches. It is also conceivable that each bird alighted and behaved in this manner at regular intervals during the flight to the feeding ground, but the limitation of time and the almost impenetrable nature of the jungle prevented the establishment of this.

Text-figure 1.—Calling stance of the Red-cheeked Parrot.

The passage to the feeding areas was over by mid-morning and only odd individuals were observed flying overhead during the remainder of the day. The return to the roosting trees was undertaken towards dusk. The singular behaviour

depicted in text-figure 1 was not observed during the return flight. While on the wing the distinctive call was emitted continuously, and this facilitated observations on movements.

Flight

Earlier observers have remarked that the flight of *G. geoffroyi* is unlike that of other Australian psittacines. This is so and indeed it resembles the flight of the introduced Starling, *Sturnus vulgaris*. It is swift, direct, and without undulation, being undertaken with short, rapid wing-beats. There is no gliding even when alighting. The fully extended wing is kept rigid when moved and there is no bending at the shoulder.

Voice

Only two calls were heard and these differed but slightly. A sharp, metallic note resembling the word "hang" repeated up to ten or more times in quick succession was the usual call. This was emitted when on the wing or when perched as depicted in text-figure 1. Imitation of the call was easy and the birds responded well. A double note resembling the above, but with a slightly alternating pitch, was given by two birds returning to roost at dusk. Feeding appeared to be undertaken in silence.

Feeding

McLennan (see Macgillivray, 1913) gave the crop and stomach contents of the first specimens as partly digested seeds, small grains of blackish gum, and yellow seeds and beans. Recent microscopic examination of the same samples by the author at the American Museum of Natural History revealed small elongated seeds, small whole kernels from native fruits, small pieces of vegetable matter with fungi attached, blackish material which may have been gum as identified above, and partly digested yellow nut or fruit matter. These crop samples, being one of the few food records for this species in Australia, are very important. The specimens collected by the author were for myological studies, and dissection was, therefore, not possible.

Feeding was observed only once, when a small flock of parrots was located midst the dense foliage near the top of a very tall tree. Unfortunately, because of the inaccessibility of this tree it could not be positively identified, but when one of the birds was taken it had adhering to its bill a quantity of fresh pinkish-red succulent fruit with many small black seeds.

Associations

G. geoffroyi was never seen to associate with the Rainbow Lorikeet, *Trichoglossus haematodus*, which was observed feeding in nearly all fruit-bearing trees in the area. Contact with the Fig Parrot, *Opopsitta diophthalma*, was also

anticipated because of alleged similar feeding habits, but this was not seen. A male *O. diophthalma* was found feeding in a *Bletharocarya involucrigera* tree together with three Rainbow Lorikeets. This isolationism shown by the Red-cheeked Parrot is noteworthy and could help to explain why it escaped detection until 1913.

Breeding and Immature Plumage

Nesting was not observed. From the many immature birds found associating with adult pairs to form family parties, it is strongly suggested that McLennan's nest (see Cayley, 1931) found in December, 1920 represented an unusual late breeding or that the young from one season remain with their parents right up to nesting in the next year.

If the latter is true the immature male collected on 4th November, 1963 (University of New England Collection) furnishes some scant information on plumage changes. This bird, which would have been at least nine months old, had the head olive-green with brownish markings, and the upper mandible brown, thus suggesting that the adult colours do not commence to show until at least the second year. An examination of skins at the American Museum of Natural History failed to establish this for the species as a whole, but did indicate that males of the race *floresianus* from Lombok Island do take more than one year to attain adult plumage. Two specimens were collected in June, 1896. AMNH.620563 has the head green with some brown markings, and the upper mandible brown, while AMNH.620567 has a brown head with some blue on the nape, some red on the cheeks, and the upper mandible red. Unless a remarkable individual variation exists in immatures, it seems that these birds were at least a season apart in age. This collection also showed that young males assumed the brown head of the adult female before attaining the red and blue. That this pattern exists in the Cape York population can only be assumed.

The presence of many immature birds at Iron Range suggested that the unique behaviour depicted in text-figure 1 could have been that of young soliciting parental feeding. If this were so, it seems strange, when the action was observed many times every morning, that no response by an adult was seen.

SYSTEMATIC DISCUSSION

The Red-cheeked Parrot of Cape York Peninsula was described as *Pseudopsittacus maclennani* by Macgillivray (1913) and was later made a subspecies of *Geoffroyus geoffroyi* (Bechstein) by Mathews (1913), who subsequently (1917) stated that it differed from *G. g. aruensis* (Gray, 1858) in being paler blue on the underwing coverts. Cayley (1938) remarked that the Australian bird also seemed larger than any he had examined from New Guinea.

The subspecies of *G. geoffroyi* may be divided into two distinct groups : those races in which the rump and back are green, and those in which these parts are marked with rusty red. With the exception of *aruensis* (Aru Islands and southern New Guinea), *maclennani* (Cape York), and also *floresianus* and *tjindanae* from the Lesser Sundas, the races of the first group are well-defined. The discussion which follows is restricted to the first two forms named, but my work suggests that the Lesser Sundas populations also require critical examination.

The comparative study of *maclennani* and *aruensis* has been greatly handicapped by the lack of adequate material from Cape York. Only five adult specimens of the former, three in Australian museums and two in New York, were available for examination. Immature specimens were not considered.

(a) Size : For *maclennani* the wing length of three adult males, including the type, is 150·5–157·7 mm (153·9 mm), and of two adult females is 153·1–153·2 mm (153·1 mm), as against 151·8–165·7 mm (158·3 mm) for ten males and 144·5–161·6 mm (150·8 mm) for ten females of *aruensis*. The measurements of the specimens of *maclennani* fall within the range of variation of *aruensis*, and, though it would be desirable to compare more measurements, it seems doubtful that any appreciable difference in size exists.

(b) Plumage: The differences in the colouration of the two forms are not constant in any character, although, generally speaking, male *maclennani* differ from male *aruensis* in having the underwing-coverts paler, brighter blue, the underparts duller green without any yellowish markings, differences that are also found in the females, and the face darker and more uniformly red. It should be emphasised, however, that all these differences are very slight and, as stated above, are not completely constant. For instance a male of *aruensis* from Samarai, New Guinea (AMNH.266953) is indistinguishable from the specimens of *maclennani* in the colour of the underparts, while in another from Dobo, Aru Islands (AMNH.620733) the colour of the underwing coverts is very similar, and a third from Trangan, Aru Islands (AMNH.620735) is identical in the colouration of the face. A female of *aruensis* from the Oetakwa River, New Guinea (AMNH.620739) resembles the females of *maclennani* in the colour of the underparts.

The above indicates that it is very desirable to compare a much larger series of *maclennani* with *aruensis*, but the apparent lack of an appreciable difference in size, together with the fact that any existing plumage differences are very slight and not completely constant in the material so far examined, suggests that it is best to synonymize *maclennani* with *aruensis* for the present.

CONCLUSION

These brief field observations carried out on the Red-cheeked Parrot have revealed some very interesting behaviour, but have also demonstrated the need for further ethological study. Despite the inadequacy of material from Cape York, comparisons have indicated that for the present it seems best to synonymize *G. g. maclennani* from this area with *G. g. aruensis* from the New Guinea region.

ACKNOWLEDGEMENTS

Gratitude is extended to the Queensland Museum, the Australian Museum, and the American Museum of Natural History for the loan of specimens.

Although the systematic conclusions are the author's personal opinions, Dr. C. Vaurie of the American Museum of Natural History gave valuable guidance and assistance with the general preparation. Dr. D. Amadon of the same museum read the manuscript.

Mr. L. S. Hall of Canberra made the line drawing.

This paper was completed while the author was working at the American Museum of Natural History under a grant from the Frank M. Chapman Memorial Fund.

LITERATURE CITED

Cayley, N. W., 1931. What Bird is That ?, 2nd edition. Sydney.

————————, 1938. Australian Parrots. Sydney.

Forshaw, J. M., 1964. Some field observations on the Great Palm Cockatoo. *Emu*, 64, pp. 327–331.

Gray, G. R., 1858. A list of the birds, with descriptions of new species obtained by Mr. Alfred R. Wallace in the Aru and Ké Islands. *Proc. Zool. Soc. London*, 26, pp. 169–198.

Macgillivray, W., 1913. Description of new parrot. *Emu*, 13, pp. 105–106.

Mack, G., 1953. Birds from Cape York Peninsula, Queensland. *Mem. Qd Mus.*, 13, pp. 1–39.

Mathews, G. M., 1913. A list of the Birds of Australia. London.

————————, 1917. The Birds of Australia, vol. VI. London.

Thomson, D. F., 1935. Birds of Cape York Peninsula. Melbourne.

THE FOSSIL PELICANS OF AUSTRALIA

ALDEN H. MILLER†
Museum of Paleontology, University of California

Among the fossil bird bones obtained in the Lake Eyre basin of Australia, remains of pelicans are not rare in the Pleistocene assemblages and one representative of this group has appeared in the mid-Tertiary deposits (Stirton, Tedford, and Miller, 1961, p. 35). No other Tertiary pelicans are known for Australia, although Pleistocene occurrences under the names of *Pelecanus grandiceps* De Vis and *P. proavus* De Vis have been on record since the turn of the century. A single species, *P. conspicillatus*, occupies the continent of Australia today.

It is the purpose of this paper to evaluate all the fossil pelican material of Australia and to describe the Tertiary form which I first regarded (Stirton, *et al.*, *loc. cit.*) tentatively as generically distinct from *Pelecanus*, but which is now judged to be a strongly differentiated species of the modern genus.

In pursuing this study, I have had the benefit of the loan of the fossil pelican material in the Queensland Museum (Q.M.) through the kindness of the late George Mack and of Alan Bartholomai. For the loan of Recent skeletons of *P. conspicillatus* I am indebted to H. J. de S. Disney and H. O. Fletcher of the Australian Museum, Sydney (A.M.), to A. R. McEvey, of the National Museum of Victoria, Melbourne (N.M.V.), and to H. T. Condon of the South Australian Museum, Adelaide (S.A.M.). Other material studied is in the collections of the University of California Museum of Paleontology (U.C.M.P.) and the University of California Museum of Vertebrate Zoology (M.V.Z.). In the field work in Australia during which fossil and Recent skeletons were collected I was particularly aided by Paul F. Lawson of the South Australian Museum and by R. A. Stirton, Richard H. Tedford, Harry J. Bowshall, and Virginia D. Miller of our field parties. Support for the work on fossil vertebrates of Australia was received from the National Science Foundation, Washington, D. C., under grants G15957 and GB1990.

TERTIARY MATERIAL

The genus *Pelecanus* is represented by several described species from the Tertiary of Europe and India and by one species from North America (see Brodkorb, 1963, pp. 265–267). The only other generic name to be taken into account in the fossil record of pelicans is *Liptornis* of South America, which is based very unsatisfactorily on a neck vertebra which has not as yet been well compared ; its familial relations seem not to have been fully elucidated, if indeed this is possible.

† Deceased 9th October, 1965.

PELECANUS TIRARENSIS sp. nov.

(Text-figure 1*a*, *c*, *e*)

HOLOTYPE.—Right tarsometatarsus, the distal end complete except for some fracturing and loss of plantar surface of trochlea IV ; shaft fragmentary, but plantar area represented between facet for digit I and beginning of ridge distal to hypotarsus ; no. P13858, South Australian Mus. ; locality no. V5762, Univ. Calif. Mus. Paleo., Lake Palankarinna, Ngapakaldi Fauna, middle Tertiary, probably late Oligocene or early Miocene ; text-figs. 1*a*, *c*, *e*.

TYPE LOCALITY.—Etadunna Formation, west side of Lake Palankarinna in Turtle quarry (V5762) ; Lake Eyre region, South Australia ; pale green, fine-grained quartz sand 2–4 feet in thickness with lenses of green argillaceous sandstone, claystone lying below and above ; abundant associated turtle and fish remains and fragmentary bird remains, including metatarsus of a gull or tern.

DIAGNOSIS.— In contrast with *P. conspicillatus*, medial surface of metatarsal II shows large pit for medial ligament ; pit situated farther distally and anteriorly and encroaching farther on articular surface of trochlea, extending almost to bottom of its groove. Posteromedial border of articular surface of trochlea II more elevated from shaft of metatarsus, thus creating a pronounced trough above it ; trough well set off from ligamental pit by an intervening ridge. Outline of trochlea less rounded viewed medially. Distal foramen less elongate on plantar surface. Mass and lateral dimensions 10 to 15 per cent. less than in females of *conspicillatus* (see table 1).

Table 1

MEASUREMENT IN MILLIMETERS OF TARSOMETATARSI OF PELICANS

——	Width across trochleae	Greatest antero-posterior dimension of trochlea III	Greatest antero-posterior dimension of trochlea II	Length from distal end scar digit I to base of hypotarsal ridge
Pelecanus tirarensis				
holotype	19·1	11·4	10·3	41·5
Pelecanus conspicillatus				
143245 M.V.Z. ♀	21·2	13·6	11·7	63·5
143248 M.V.Z. ♀	21·5	14·0	11·5	66·0
B11469 S.A.M. [♀?*] ..	22·0	13·7	12·0	63·5
S1206 A.M. [♀?*]	21·9	14·3	12·1	67·5
S1207 A.M. [♀?*]	22·0	14·2	12·1	66·0
143249 M.V.Z. ♂	24·3	14·7	12·9	69·0
W5982 N.M.V. ♂	24·6	15·1	13·0	75·5
Pelecanus grandiceps				
lectotype	—	16·9	—	—
56322 U.C.M.P.	—	16·6	—	—

* Sex suggested by size

Additional Features.—The fragments of the shaft of *P. tirarensis* which are present (see text-fig. 1) do not make perfect contact with the distal segment. On the shaft the articular surface for metatarsal I is clearly represented. It is more deeply excavated and more sharply flanged medially than in *conspicillatus*. The distance between it and the beginning of the plantar ridge that rises to the hypotarsus is one-third less than in *conspicillatus*, suggesting that the shaft and thus the entire tarsometatarsus was much shorter than in the modern species, and quite out of proportion to the slightly lesser size otherwise. However, the shaft fragments, although seemingly fitted together correctly, are not to be relied upon to register the total length with precision. The shorter shaft in relation to distal width approximates the condition in the modern short-legged brown pelican, *P. occidentalis*, although in the important matter of the configuration of trochlea II there is no similarity.

Text-figure 1.—Tarsometatarsi of pelicans, natural size. *a*, type of *Pelecanus tirarensis*, medial view; *b*, modern *P. conspicillatus*, no. 143245 M.V.Z., medial view; *c*, type of *P. tirarensis*, plantar view; *d*, *P. conspicillatus*, plantar view; *e*, *P. tirarensis*, anterior view; *f*, *P. conspicillatus*, anterior view. Drawings by Augusta Lucas.

Comparisons.—Very little advance in knowledge of Tertiary pelicans has been made since the end of the last century. Lydekker (1891, pp. 37–45) reviewed the material known up to that time. Two species from the Pliocene of India, *P. cautleyi* and *P. sivalensis*, had been described by Davies (1880, p. 26). Both are based on distal ends of ulnae, although some fragments of other elements have been referred to them. Both were described as smaller than the living *P. roseus* of south-east Asia. Accordingly they cannot be compared with *P. tirarensis* which is known only from the tarsometatarsus, although they may have been in the same size range. *P. gracilis* Milne-Edwards (1867, p. 250) from the Oligocene (Aquitanian) of France was based primarily on the upper part of a tarsometatarsus; nothing is known of the lower articular surfaces of the bone which would be critical in relating it to *tirarensis*. *P. gracilis* was a very much smaller, more slender-legged bird than *conspicillatus*, as Milne-Edwards' descriptions and figures show. *P. intermedius* Fraas (1870, pp. 281–283) from the Upper Miocene of Germany is based on a cranium and parts of the bill. Much other material has been referred to it (Lydekker, 1891, pp. 40–44; Lambrecht, 1933, p. 277), including tarsometatarsi, but these are not of proved association with the type material and moreover have not been described and critically compared. *P. fraasi* Lydekker (1891, p. 44) from the Upper Miocene of Bavaria was also based on a cranium, differing strongly in osteologic features from *intermedius*, but the lower leg bones of this species are unknown.

P. odessanus Widhalm[1] (1886, p. 6) from the Lower Pliocene of Odessa is based on a tarsometatarsus. The large size (tarsometatarsus 150 mm long) indicates a bird similar to *conspicillatus*, but if the description and figures are to be trusted, it differed rather radically from the configuration of *conspicillatus* and other modern pelicans in the shape of the trochleae and in the ridges and muscle scars of the metatarsus. It shows no approach whatsoever to the peculiar configuration of trochlea II seen in *tirarensis*.

P. halieus Wetmore (1933, p. 3) was described from the Hagerman Lake beds in Idaho. This has variously been regarded as Upper Pliocene or Lower Pleistocene. The species is based on the distal end of a radius and is not comparable, therefore, with the Australian Tertiary species; it obviously was a much smaller bird.

[1]Brodkorb (1963, p. 266) and Lambrecht (1933, p. 295) both misspelt this name, and the former, apparently not able to consult the original paper and following Lambrecht's incorrect reproduction of the name of the species, assumed Widhalm did not offer a proper binomial designation of the species, whereas he appears to have done so as follows: " . . . . unter den Namen seiner Vaterstadt als *Pelecanus odessanus*. fossilis *Widhalm* in die Gesellschaft seiner Artgenossen einzuführen " (original italicization and punctuation are preserved). Thus the species name *odessanus* is properly derived from Widhalm (1886) and not from Lambrecht (1933). I am indebted to Bobb Schaffer for assistance in locating the original Widhalm reference in the Osborn Library at the American Museum of Natural History and providing me with a photographic copy of it.

The foregoing review indicates that on present evidence *P. tirarensis* is distinctly different from all other known Tertiary pelicans based on the same parts of the skeleton, and that those species described from other elements show no particular features of size or build that would suggest identity with it. Moreover representatives of the three modern subgenera of pelicans, the brown, white, and Australian pelicans, show no approach to *tirarensis* in the shape of the second trochlea.

Discussion.—The Tertiary record of the family Pelecanidae is surprisingly scant and it has not been significantly augmented in recent years. The characteristics of *P. intermedius*, *P. fraasi*, *P. odessanus*, and *P. tirarensis* reflect a stronger differentiation of species in the genus in the Tertiary than that between the living species. The substantial divergences represented by the first three and the comparable divergence of *tirarensis* have led me to include *tirarensis* in this broad generic grouping, rather than separate it further as was my earlier inclination.

Unfortunately the functional meaning of the distinctive tarsal configuration of *tirarensis* cannot be assessed. One may assume that it reflects stronger ligaments on the medial side of the base of digit II than in the living species, but without an analysis of the musculature operating or bracing this toe nothing definite can be concluded about action. In general the structure suggests greater strength of the foot in bracing and grasping.

PLEISTOCENE MATERIAL

The Pleistocene pelicans of Australia bear two names proposed by De Vis (1892, 1906). He evidently proceeded on the general belief that all fossils should be designated as separate species, whether or not they differed significantly from their modern relatives. In view of this a careful appraisal of his descriptions and original materials seems necessary, for many of the late Pleistocene specimens he worked with may indeed be inseparable from the living *P. conspicillatus*. The specimens of the latter which we collected and borrowed (see table 1) serve fairly adequately to show its range in size and the variability of its osteologic characters. It must be realized that at the turn of the century, when De Vis worked, there was very little awareness of the problems of variability and a typological approach prevailed. Usually a comparative osteologist was content with the examination of a single skeleton of a given species.

De Vis (1892, p. 444) based the species *P. proavus* on the distal end of a tarsometatarsus from the Darling Downs beds in Queensland, and not as Brodkorb (1963, p. 267) indicates on a fragmentary carpometacarpus. The latter was mentioned by De Vis only in passing and he gave no differentiating characters for it and did not figure it. Among the material extant at the Queensland Museum, the tarsometatarsus is lacking and it is therefore to be concluded that it is lost. A crushed proximal end of a carpometacarpus is present and it evidently is the one

De Vis mentions. He says of this that it has "a large pneumatic foramen placed as in *Pelicanus*; the bone is too much crushed and distorted to allow of a description of any value." The specimen, no. F.1141 Queensland Museum, does appear to have the foramen referred to, although it may be unnatural and resulting from the crushing. The shape of metacarpal I and its processes, which are fairly well preserved, differs radically from that of pelicans and is more suggestive of that of *Grus*. This fragment had best be regarded, then, as indeterminate and removed from any consideration as a representative of the Pelecanidae.

The type of *proavus*, the tarsometatarsus, is described by De Vis in some detail, and from this and the figure it is quite clear that it represents *Pelecanus*. The differentiation from *conspicillatus* which he makes is based entirely on size: "the living species exceeds the extinct by one-fourth of the latter." The measurements which he cites appear to support this. The figures of the tarsometatarsus are apparently reproduced at natural size, although this is not stated, and one must acknowledge that there might have been some deviation from this in the engraving. One measurement De Vis gives is the "width across the trochlear expansion" as 16·5 mm. This apparently does not represent the maximum width across the trochleae and their lateral processes, which are obviously broken and incomplete, but rather the width proximal to that point at the level of the distal foramen. This measurement I can duplicate exactly by measuring on the figure. By contrast De Vis gives a single figure for the same dimension in *conspicillatus* as 20 mm. The two known females of the living form listed in table 1 measure 16·5 and 16·7 mm at this point, and the two males about 20·0 mm. Moreover, superposition of the metatarsus of female no. 143245 on the figure shows it to match almost perfectly in size. The other dimension given by De Vis, "the distance from the proximal end of the hallucal depression" to the end of the bone is not significant, for the proximal end of that scar is lacking in the fossil as figured. Again a superposition of the metatarsus of no. 143245 on the figure shows no difference in dimensions on the long axis of the bone. Moreover, I detect in the figure no aspects of shape that suggest differences from the modern bird.

I am therefore forced to conclude that *P. proavus* falls within the size range of the modern *P. conspicillatus* and that there are no characters differentiating the two. *Pelecanus proavus* must therefore be regarded as a synonym of *P. conspicillatus*.

In naming *P. grandiceps*, De Vis (1906, p. 16) described and figured a quadrate, a coracoid, and a tarsometatarsus, the latter two fragmentary. All the original material is before me for analysis and I find that De Vis' illustrations are natural size and reasonably accurate representations.

The quadrate of *grandiceps* in comparison with that of modern males is not larger as claimed. For example it is equalled or slightly exceeded by no. 11849 A.H.M., a pick-up modern skull from Cooper Creek, Australia, in the same dimensions

used by De Vis (p. 16). It is interesting that his rather unjustified extrapolation of the total head length of 21 inches is also exceeded in this modern bird, in which it is 22 inches long. In this particular study, De Vis must not have had at hand a large male of *conspicillatus*.

The configuration of the quadrate which he mentions in respect to the pterygoid articulation I find quite variable in the modern material, in some cases essentially duplicating the fossil. The difference in size of a foramen and the distinctness of certain ridges are variable features which are not meaningful, and the squamosal articulation is not in fact broader than in *conspicillatus* as was claimed.

The coracoidal fragment included in De Vis account is too incomplete, as De Vis says, "to supply further information" about this Pleistocene form. It was from a bird as large as males of the modern species and may have exceeded the examples at hand slightly in shaft width.

The distal end of the tarsometatarsus is indeed conspicuously large. I cannot be sure how De Vis took the length measurements of trochlea III which he cites, and I find it difficult to specify the degree of difference in dimension along the linear axis because of the incompleteness of the distal surface. The most significant measurement that can be taken is that of the greatest anteroposterior distance across trochlea III, which is 16·9 mm. Compared with the largest male of the modern species, which is 15·1 mm, this is a 12 per cent. difference and a greater difference than that between the smallest female and the largest male in the sample of seven available. This measurement in the fossil exceeds the mean for *conspicillatus* by more than three times the standard deviation and thus falls outside its range of variability. Other parts of the fossil metatarsus are similarly large as judged by general comparison with males of *conspicillatus*. For example the breadth of the facet for metatarsal I and the length of the distal foramen, though not precisely measureable, are of the order of 15 to 20 per cent. greater than in males of *conspicillatus*. Two aspects of configuration are worth noting, namely a greater breadth and flattening of the trochlear ridges on the anterior surface and the presence of a deep pit on the plantar surface between the bases of trochleae III and II. These features in combination seem sufficient to support the view that this tarsometatarsus represents a large species different from the modern pelican.

De Vis' name *grandiceps* rests, then, on three unassociated specimens, although they came from the same general Pleistocene locality of Cooper Creek. He designated no holotype and a type designation subsequently has not been published so far as I am aware. To conserve the existing name I designate the tarsometatarsal fragment, no. F.3751 Queensland Museum, as the lectotype of *Pelecanus grandiceps* and relegate the two other specimens which constituted De Vis' type material, namely the quadrate and the coracoid, to *P. conspicillatus*.

Additional Material.—Fragmentary remains of pelicans were obtained in early and late Pleistocene localities in the course of the recent field work in the Lake Eyre basin. Only one of these, a metatarsal fragment, is of the size of *P. grandiceps*. The following additional material all belongs to *P. conspicillatus*.

Early Pleistocene, Katipiri Sands, Lake Kanunka, Kanunka Fauna. Locality V5773, site 2, *in situ*, Univ. Calif. Mus. Paleo.: no. 60549, right cuneiform, complete ; no. 60577, distal end of right tarsometatarsus, the surfaces of trochlea II eroded ; no. 60578, distal end of right tarsometatarsus, trochlea II somewhat crushed ; no. 69587, fragment of proximal articulation of right humerus (float on surface).

Both metatarsal fragments are small. The only dimension that can be taken satisfactorily across adequately preserved surfaces is that of the anteroposterior dimension of trochlea III. One, no. 60578, is 12·3 mm and the other 11·3 mm. These are intermediate in the one case between *conspicillatus* and *tirarensis* and in the other case equivalent to *tirarensis*. This small size in itself is not sufficient grounds to view these as importantly different from modern *conspicillatus*, and affinity or approach to *tirarensis* is not supported by the shape of residual parts of trochlea II. In these matters of configuration these early Pleistocene fragments correspond with *conspicillatus*.

Late Pleistocene, lower Cooper Creek, Malkuni Fauna. Locality V5860, site 8, Univ. Calif. Mus. Paleo. : no. 56321, left quadrate, complete ; no. 60487, fragment of a coracoid ; no. 60477, proximal end of right femur ; no. 60520, distal end of left ulna ; no. 60503, left cuneiform ; no. 60521, distal end of right tibiotarsus. Locality V5859, site 7 : no. 56394, part of a cervical vertebra. Locality V5868, site 16 : no. 56348, distal end of left ulna. Locality V6147, site 18 : no. 60656, fragment of anterior end of sternum with coracoidal facets ; no. 60640, distal articular surface of left humerus. Locality V5382, Malkuni waterhole : no. 60702, fused palatines, essentially complete.

All this late Pleistocene material was found on the surface as outwash from the Katipiri Sands in the drainage channel of Cooper Creek. None of it departs in size or configuration from modern *conspicillatus*. A few elements slightly exceed the examples of males of the latter, but not to a degree to suggest the substantially larger *P. grandiceps*.

A fragment of a distal end of a left tarsometatarsus, no. 56322, from V5860, site 8, on Cooper Creek, is of essentially the same size (table 1) and configuration as the lectotype of *P. grandiceps* and thus is the only sure additional material of that extinct late Pleistocene form.

De Vis (1906, p. 17) assigned a tibiotarsus and a femur from lower Cooper Creek to *P. proavus*. These are before me and I cannot separate them from *conspicillatus*. The femur, on which he comments in particular, was I believe to some extent misinterpreted by him owing to the incompleteness of the condyles. All elements originally and subsequently ascribed to *proavus* therefore fall under *conspicillatus*.

SUMMARY

The record of fossils of the family Pelecanidae in Australia extends from the mid-Tertiary (late Oligocene or early Miocene) to the late Pleistocene. Most of the material is from the Lake Eyre basin. A new species of pelican, *Pelecanus tirarensis*, from the Tertiary, is described, a species differing from other pelicans chiefly in the configuration of the second metatarsal. It was shorter legged but otherwise only slightly smaller than the modern *P. conspicillatus*.

In the early Pleistocene the modern species occurred in the Lake Eyre region; it may at that time have tended toward somewhat smaller size than today, but it shows none of the important features of *tirarensis*.

The late Pleistocene remains of pelicans are all of the species *conspicillatus* both in the Darling Downs locality and in the Lake Eyre region, with the exception of *P. grandiceps* De Vis based on a very large tarsometatarsus, one further fragment of which was found.

A review of nearly all of De Vis' fossil material reveals that his *P. proavus* is a synonym of *P. conspicillatus* and that his *P. grandiceps* was a composite. A lectotype for *grandiceps* has been designated and the remaining type material assigned to *conspicillatus*.

LITERATURE CITED

Brodkorb, P., 1963. Catalogue of fossil birds. Part 1. *Bull. Florida State Mus.*, 7, pp. 179–293.

Davies, W., 1880. On some fossil bird-remains from the Siwalik Hills in the British Museum. *Geol. Mag.*, decade 2, 7, pp. 18–27, pl. 2.

De Vis, C. W., 1892. Residue of the extinct birds of Queensland as yet detected. *Proc. Linn. Soc. N.S.W.*, Ser. 2, 6, pp. 437–456, pls. 23–24.

———, 1906. A contribution to the knowledge of the extinct avifauna of Australia. *Ann. Qd Mus.*, no. 6, pp. 3–25, pls. 1–9.

Fraas, O., 1870. Die Fauna von Steinheim mit Rücksicht auf die Miocänen Saugethierund Vogelreste des Steinheimer Beckens. *Jahrs. Ver. für vaterl. Naturk. Württemberg, Stuttgart*, 26, pp. 145–406, pls. 4–13.

Lambrecht, K., 1933. Handbuch der Palaeornithologie. Gebrüder Borntraeger, Berlin, xix + 1024 pp., 209 figs.

Lydekker, R., 1891. Catalogue of the fossil birds in the British Museum. London, xxvii + 368 pp., 74 figs.

Milne-Edwards, A., 1867–1868. Recherches anatomiques et paléontologiques pour servir a l'histoire des oiseaux fossiles de la France. G. Masson, Paris, vol. 1, 474 pp.

Stirton, R. A., Tedford, R. H., and Miller, A. H., 1961. Cenozoic stratigraphy and vertebrate paleontology of the Tirari Desert, South Australia. *Rec. S. Aust. Mus.*, 14, pp. 19–61, figs. 1–4.

Wetmore, A., 1933. Pliocene bird remains from Idaho. *Smithsonian Misc. Coll.*, 87 (20), pp. 1–12, figs. 1–8.

Widhalm, J., 1886. Die fossilen Vogel-knochen der Odessaer Steppen-Kalk-Steinbrüche der Neuen Slobodka bei Odessa. *Schrift. Neuruss. Gesell. Naturf. Odessa*, 10, pp. 1–10, pl. 5.

A REVISION OF THE BLASTOIDS "*MESOBLASTUS* ? *AUSTRALIS*," "*GRANATOCRINUS* ? *WACHSMUTHII*," AND "*TRICOELOCRINUS* ? *CARPENTERI*," DESCRIBED BY ETHERIDGE (1892) FROM THE CARBONIFEROUS OF QUEENSLAND

R. G. McKellar

Geological Survey of Queensland

ABSTRACT

The type specimens of the three blastoids, *Mesoblastus* ? *australis*, *Granatocrinus* ? *wachsmuthii*, and *Tricoelocrinus* ? *carpenteri*, described by Etheridge (1892) from the "Permo-Carboniferous Gympie Beds" of the Rockhampton district, Queensland are shown to be conspecific. The species is redescribed and its morpology considered to be sufficiently distinctive to warrant its assignment to a new genus, for which the name *Malchiblastus* is proposed, with *Mesoblastus* ? *australis* as type species. The genus is tentatively regarded as a member of the Granatocrinidae, and its affinities discussed. From the associated fauna a probable middle Westphalian age is suggested.

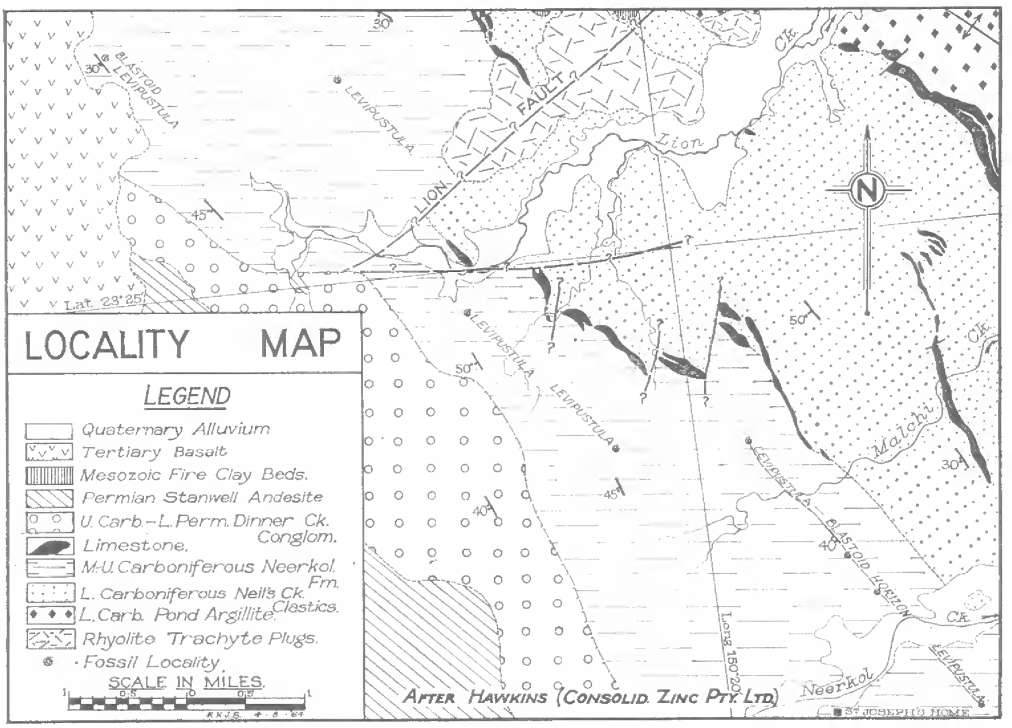
Etheridge (1892) described and figured three incomplete blastoids from the "Permo-Carboniferous Gympie Beds" of the Rockhampton district as *Mesoblastus ? australis*, *Granatocrinus ? wachsmuthii* and *Tricoelocrinus ? carpenteri*. Re-examination of the three type specimens, in the first instance by Mr. J. T. Woods, Director of the Queensland Museum, and subsequently by the author, has shown them to be conspecific.

The diversity of appearance exhibited by these specimens seems to result principally from the severe crushing experienced subsequent to burial, and also from the mode of preservation as internal and external moulds. *M.* ? *australis* was based on the external mould of an immature calyx which had been crushed almost flat and its constituent plates dislocated and fractured. The type of *T.* ? *carpenteri* is the internal mould of a large incomplete calyx, similarly flattened, but with relatively little plate dislocation. Its counterpart, an external mould, was also present in the Queensland Museum (Q.M.) collections, but was apparently overlooked by Etheridge. Each of these specimens (preserved in an indurated, fine, lithic sandstone) was collected by E. K. Ogg in 1886 from the Rockhampton district. The precise locality is unknown, but the material compares closely with specimens

in the Geological Survey of Queensland (G.S.Q.), collected by W. H. Rands in 1891 from Malchi Creek, approximately $3\frac{1}{4}$ miles east-north-east of Stanwell, in the lower part of the Neerkol Formation (text-fig. 1). Three of the specimens collected by Rands were borrowed by J. A. Bather of the British Museum in 1893, but to the best of my knowledge, results of his examination were never published. *G. ? wachsmuthii*, the most fragmentary specimen, is essentially the external mould of a single deltoid, fractured along its length, and portion of the adjacent ambulacrum. It was collected by J. Smith in 1890 from Stanwell, probably along Neerkol Creek. The species was tentatively reassigned to the genus *Orbitremites* by Bather (1899), but no reasons were advanced for the change.

Following these early collections of Ogg, Smith, and Rands, no further blastoids were discovered in the area until 1962, when Professor D. Hill and Mr. G. W. Tweedale collected two incomplete specimens from the Neerkol Formation, $7\frac{1}{2}$ miles north-west of Stanwell ($\frac{3}{4}$ mile along a track diverging to the east from the Stanwell to Dalma road, about 8 miles from Stanwell). Three additional blastoids were later collected by the author from this locality.

Terminology applied in description of blastoid morphology follows that of Fay (1961b).



Text-figure 1.—Blastoid localities near Stanwell, Q.

Order **SPIRACULATA** Jaekel, 1918

Family ? **GRANATOCRINIDAE** Fay, 1961

Genus **MALCHIBLASTUS** nov.

TYPE SPECIES.—*Mesoblastus* ? *australis* Etheridge, 1892; Upper Carboniferous (Westphalian).

DIAGNOSIS.—Large subfusiform to narrowly conical blastoids, with moderately short pelvis at maturity. Radials long, the substance of the plate continuous beneath the ambulacra. Deltoids a little shorter than radials; two spiracles embayed near adoral extremity. Radials overlap deltoids; radio-deltoid suture V-shaped in juveniles, M-shaped at maturity. Ambulacra linear, side plates very numerous, lancet exposed medially; one large pore between each side plate along deltoid and radial margins. Four very short hydrospire folds on each side of ambulacra; aboral to radio-deltoid suture folds enter radials, splay abmedially and terminate within a short distance.

The characters of this blastoid clearly establish that it belongs to a new genus, even though the disposition of deltoids in the anal interarea, and the relation of spiracles to the anus are not known. The name *Malchiblastus* is derived from Malchi Creek near Stanwell.

The subfusiform to steeply conical calyx shape, together with the presence of two spiracles in each deltoid, relates *Malchiblastus* with genera listed in the classification of Fay (1964, pp. 84–5) as members of the families Troosticrinidae Bather and Granatocrinidae Fay.

Among the Troosticrinidae, *Tricoelocrinus* Meek and Worthen, from the Mississippian of North America, has much in common with *Malchiblastus*, particularly in the structure of the hydrospires and radial plates. Fay (1961b, p. 104) has indicated that *T. woodmani* (Meek and Worthen), the type, has "three short hydrospire folds on each side of an ambulacrum extending only one-half way down each ambulacrum and ending within the substance of the thick radial plates beneath the ambulacra". The termination of the hydrospires in the adoral portion of the thickened radial of *T. obliquatus* (Roemer) was illustrated by Etheridge and Carpenter (1886, pl. 18, figs. 10–13). The structures are closely analogous to those in *Malchiblastus* and it is likely that Etheridge (1892, p. 212) was influenced by them when he tentatively referred his single internal mould to *Tricoelocrinus*. In both genera radials overlap deltoids at their adoral margin. Although apparently allied in the above respects, *Tricoelocrinus* is readily distinguished by its broadly flaring radials and short deltoids, and by its paired spiracles (Fay, 1961a, p. 90, text-figs. 1, 2).

Schizotremites Reimann from the Middle Devonian of North America has a broadly similar calyx shape to *Malchiblastus*, but the deltoids are very short, the spiracles narrow, closely spaced and slit-like, and the hydrospires (4–6) are pendent and apparently extend the length of the ambulacrum. Macurda (1964, p. 108) recommended that the use of the term "paired" in description of its spiracles should be avoided, although Fay (1964, p. 84) included *Schizotremites* in the Troosticrinidae, characterised by "five paired spiracles; theca conical".

The type species of *Pyramiblastus* Macurda, *P. fusiformis* (Wachsmuth and Springer), is more closely comparable, in calyx shape and proportions, to *Malchiblastus australis* than any other blastoid known to the author; this applies particularly to immature specimens of the latter, in which vault and pelvis are nearly equal. Spiracles in *Pyramiblastus*, like those of *Schizotremites*, are very closely spaced, but separated by a narrow crest; they seem transitional between the paired condition of the Troosticrinidae and the clearly separated condition of the Granatocrinidae. In addition to its very closely spaced spiracles, *P. fusiformis* differs from *M. australis* in its adorally embayed radials, the manner in which deltoids overlap radials, and the occurrence of six hydrospires in each group. It is not clear from descriptions of the species whether hydrospires are short or pendent. *Pyramiblastus* is known only from the Lower Mississippian of North America.

Calycoblastus Wanner from the Permian of Timor is the only genus referred by Fay (1964) to the Granatocrinidae that has similar calyx shape to *Malchiblastus*; all other genera, including *Mesoblastus* Etheridge and Carpenter and *Granatocrinus* Hall, to which specimens of *M. australis* were tentatively referred by Etheridge (1892), have a somewhat globose calyx. *Calycoblastus* is distinguished by its relatively short deltoids, side plates which completely cover the lancet, five pendent hydrospires, and fused hydrospire plate (Wanner, 1924, p. 39, fig. 7).

Bather (1899) referred "*G.?wachsmuthii*" to *Orbitremites* Austin and Austin. This genus has a globular calyx, only five spiracles and one hydrospire fold on each side of the ambulacra.

Malchiblastus is tentatively placed in the Granatocrinidae on the basis of its relatively well separated spiracles and calyx shape. The structure of the hydrospires and radials suggests that it may have evolved from *Tricoelocrinus*, even though calyx shape is most like that of *Pyramiblastus*.

MALCHIBLASTUS AUSTRALIS (Etheridge fil.)

(Plate 24, figures 1–7)

Mesoblastus ? *australis* Etheridge, 1892, p. 210, pl. 44, fig. 2.

Granatocrinus ? *wachsmuthii* Etheridge, 1892, p. 211, pl. 7, fig. 10.

Tricoelocrinus ? *carpenteri* Etheridge, 1892, p. 212, pl. 44, fig. 3.

Orbitremites ? *wachsmuthi* (Etheridge), Bather, 1899, p. 32.

MATERIAL.—Holotype, F.1193 (Q.M.) (holotype of *Mesoblastus* ? *australis* Etheridge) probably from the lower part of the Neerkol Formation, Malchi Creek, Stanwell. Figured specimens, F.1195 (Q.M.) (holotype of *Tricoelocrinus* ? *carpenteri* Etheridge), F.8289 (G.S.Q.), F.8294 (G.S.Q.), all probably from the lower part of the Neerkol Formation, Malchi Creek, Stanwell; F.1591 (G.S.Q.) (holotype of

Granatocrinus ? wachsmuthii (Etheridge), probably from Neerkol Creek, Stanwell. Mentioned specimen, F.9452 (G.S.Q.), from 7½ miles north-west of Stanwell (map reference 178855 Ridgelands 1-mile military sheet). Four other incomplete specimens from Malchi Creek, two from Neerkol Creek downstream from St. Joseph's Home, and four from 7½ miles north-west of Stanwell.

Diagnosis.—As for genus.

Description.—The calyx is large, subfusiform to steeply conical in side view, pentagonal in oral view. Vault slightly greater than pelvis in the young, but towards maturity the vault approaches three-quarters of the calyx height. Greatest width is at the aboral extremities of the ambulacra.

The basal circlet has three moderately spreading, normally disposed plates which form an inverse cone between one-third and one-half the height of the pelvis. The azygous basal is quadrilateral, the larger plates hexagonal. Strong growth lines parallel to the inter-basal and basi-radial sutures mark the surface of these plates.

The length of the stem is not known, but 1 cm of it is preserved in F.9452 (G.S.Q.). It is 1·8 mm in diameter and composed of thin disc-like columnals 0·3–0·4 mm thick, each centrally pierced by a round lumen 0·25 mm in diameter. An extremely fine narrow flange 0·25 mm wide encircles each columnal about the midline.

The five radials are elongate, and have almost parallel sides. Growth is most rapid at adoral margins of the radial limbs and the ratio (length radial limb : length plate body) increases from 1 : 1 in juveniles to approximately 3 : 1 in adults. This change in proportions of the radials is reflected in calyx shape, which is transitional from an early subfusiform outline to an almost conical form. In addition, adoral margins of limbs become increasingly peaked towards maturity, allied with distal broadening of ridges laterally bordering the sinus ; the overall effect is to produce an eight-sided radial and sharply M-shaped radio-deltoid suture. Radials clearly overlap deltoids. The species is particularly interesting as the inner surface of the radial is continuous beneath the ambulacrum. In the young this under-sheath is very thin, but towards maturity it becomes heavily thickened and an elevated wedge shaped area is formed on the inner surface of the calyx. The lancet is supported in a broad, rounded, median longitudinal groove on its upper surface. Radials are ornamented by prominent growth lines and fine granules aligned parallel to the plate margins.

The four deltoids are widely lancet-shaped and a little shorter than the radials. Broad ridges at their lateral margins are continuous with those on adjacent radial limbs. Just aboral to the adoral extremity of each deltoid (0·5 mm), lateral margins are embayed by a pair of elongate spiracles, each approximately 1·3 mm in length. In this apical portion of the deltoid, the inner surface is thickened and elevated to form a low platform, and expands laterally as a narrow ledge which projects beyond the plate margins visible in external view. In mature specimens the platform is 3·5–4 mm long and two fine parallel ridges extend proximally for 2 mm from its aboral margin. On F.8289 (G.S.Q.) deltoids are 1·2 mm thick medianly. They are ornamented by very strong growth lines parallel to the radio-deltoid suture, but usually no granules. A pair of exceedingly fine, linear surface incisions extend from the apical area of each deltoid, just inside the marginal ridge to the aboral margin ; their presence cannot be explained. The arrangement of deltoids in the anal interarea is not known.

Five linear ambulacra have the lancet covered by side plates, except in the median line where it is exposed over 0·1 mm along the entire length. Side plates are moderately broad and 80–85 are present on each side of an ambulacrum, i.e. approximately 2 per millimetre. Outer side plates at adoral abmedial edges of side plates are small and almost semi-circular in outline. Triangular pores lie between aboral margins of side plates, adoral margins of outer side plates and the adjacent radial or deltoid margin. Beneath the side plates, between the lancet and radial or deltoid the pores are circular and have a diameter of 0·2–0·25 mm. Side plates bear a pronounced pore furrow on their outer face, and eight cover plate sockets admedially.

Four hydrospire folds appear to be developed on each side of the ambulacra ; they are very short and appear as low rounded ridges on the inner surface of the calyx. Aboral to the radio-deltoid suture the folds enter the substance of the radial, splay abmedially, the outermost almost at right angles to the ambulacrum, and terminate within a short distance.

DIMENSIONS (mm)

	CALYX	BASALS	DELTOIDS	RADIALS	AMBULACRA
	length width	length width	length width	length width	length width
F.1193 (Q.M.) Holotype	24 x 16	4 x 5	8 x 5	13 x 7	15 x 2
F.1195 (Q.M.) fig. spec.	— x 28	— x —	23 x 12	23 x 17	40 x 2·6
F.8294 (G.S.Q.) fig. spec.	— x —	— x —	21 x 14	23 x 17	42 x 2·6

N.B.—Specimens are crushed almost flat and width measurements of the calyx considerably exaggerated.

Of the three names used for the conspecific blastoids by Etheridge (1892), *Mesoblastus ? australis* has page priority, and hence *Granatocrinus ? wachsmuthii* and *Tricoelocrinus ? carpenteri* are regarded as its synonyms. It should perhaps be noted that the specific name *wachsmuthii* is almost certainly a misprint in the heading to Etheridge's description (1892, p. 211), as it is spelled *wachsmuthi* elsewhere in that publication.

Malchiblastus australis is directly associated with a moderately diverse fauna which includes *Fistulamina frondescens* Crockford, *Fenestella micropora* (Crockford), *Polypora neerkolensis* Crockford, *Streptorhynchus* sp., *Levipustula levis* Maxwell, *Spinuliplica spinulosa* Campbell, *Sanguinolites* sp., and *Acrocrinus* sp. The fauna is typical of the *Levipustula* beds in the lower part of the Neerkol Formation, which Maxwell (1951) regarded as Moscovian in age. The age determination was confirmed by Campbell (1961), who described a closely comparable fauna, including a blastoid radial like those of *M. australis*, from the Booral Formation (Upper Kuttung Series) in New South Wales, and deduced a probable middle Westphalian age.

Two other Carboniferous blastoids are known from the Monto district in Queensland. *Nymphaeoblastus bancroftensis* McKellar was described from Lower Carboniferous (Viséan) strata $3\frac{1}{2}$ miles east-south-east of Bancroft (McKellar, 1964), and a single long deltoid has recently been collected by the author from the Westphalian Branch Creek Formation, 4 miles east of Dakiel.

ACKNOWLEDGEMENTS

The writer wishes to thank Mr. J. T. Woods (Queensland Museum) for the loan of two of Etheridge's type specimens, Dr. D. B. Macurda Jr. (University of Michigan) for his valuable comments on the blastoids morphology, and C. R. A. Exploration Pty. Ltd. for permission to use geological maps of the Mt. Morgan–Rockhampton district, compiled for them by B. Hawkins and I. G. Whitcher, in the preparation of the locality map.

LITERATURE CITED

Bather, F. A., 1899. The genera and species of Blastoidea, with a list of specimens in the British Museum (Natural History). London.

Campbell, K. S. W., 1961. Carboniferous fossils from the Kuttung rocks of New South Wales. *Palaeontology*, 4, pp. 428–474.

Etheridge, R. Jr., 1892, *in* Jack, R. L., and Etheridge, R. Jr. The geology and palaeontology of Queensland and New Guinea. *Publ. geol. Surv. Qd*, 92, pp. 1–768.

Etheridge, R. Jr., and Carpenter, P. H., 1886. Catalogue of the Blastoidea in the Geological Department of the British Museum (Natural History). London.

Fay, R. O., 1961a. The type of *Tricoelocrinus* Meek and Worthen. *Okla. Geology Notes*, 21, pp. 90–94.

———, 1961b. Blastoid studies. Echinodermata, Art. 3. *Univ. Kansas, Paleont. Contrib.*, 27, pp. 1–147.

———, 1964. An outline classification of the Blastoidea. *Okla. Geology Notes*, 24, pp. 81–90.

Macurda, D. B. Jr., 1964. A new spiraculate blastoid, *Pyramiblastus*, from the Mississippian Hampton Formation of Iowa. *Contrib. Mus. Pal., Univ. Michigan*, 19, pp. 105–114.

Maxwell, W. G. H., 1951. Upper Devonian and Middle Carboniferous brachiopods of Queensland. *Pap. Dep. Geol. Univ. Qd*, 3 (14), pp. 1–27.

McKellar, R. G., 1964. A new species of *Nymphaeoblastus* (Blastoidea) from the Lower Carboniferous of Queensland. *Mem. Qd Mus.*, 14, pp. 101–105.

Wanner, J., 1924. Die Permischen Echinodermen von Timor. Teil 2. *Pälaont. Timor*, 14 (23), pp. 1–81.

EXPLANATION OF PLATE XXIV

Malchiblastus australis (Etheridge fil.)

Fig. 1. Side view of deltoid and portion of ambulacrum, F.1591 (G.S.Q.), holotype of *Granatocrinus ? wachsmuthii* Etheridge fil. Latex cast from external mould, X 2.

Fig. 2. Side view of incomplete calyx, F.1195 (Q.M.), counterpart of holotype of *Tricoelocrinus ? carpenteri* Etheridge fil. Latex cast from external mould, X 1·5.

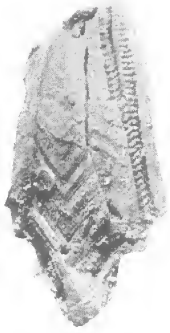
Fig. 3. Side view of internal mould of calyx, F.1195 (Q.M.), holotype of *Tricoelocrinus ? carpenteri* Etheridge fil., X 1·5.

Fig. 4. Side view of holotype, a severely crushed calyx, F.1193 (Q.M.). Latex cast from external mould, X 2.

Fig. 5. Side view of immature calyx, F.8294 (G.S.Q.). Latex cast from external mould, X 2.

Fig. 6. Oblique detailed view of ambulacrum, F.1195 (Q.M.), same specimen as fig. 2. Latex cast from external mould, X 8.

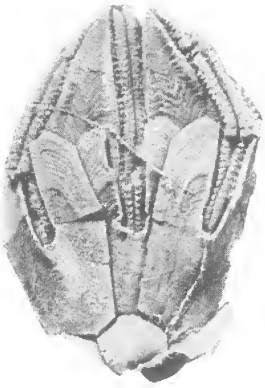
Fig. 7. Side view of large crushed calyx, F.8289 (G.S.Q.). Latex cast from external mould, X 1·5.



1

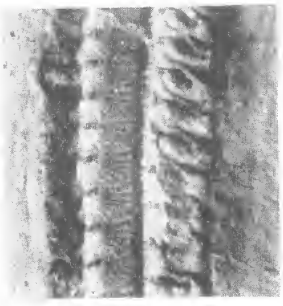
2

3

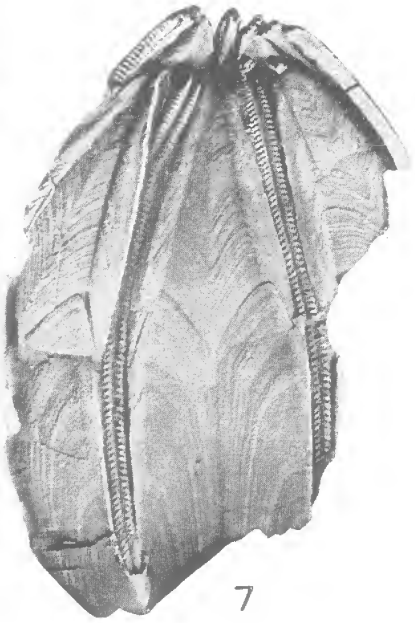


4

5



6



7

AN AMMONOID FROM THE PERMIAN OF QUEENSLAND

J. F. Dear

Geological Survey of Queensland

ABSTRACT

Uraloceras cancellatum sp. nov. is described from the Yarrol Formation in the Yarrol Basin near Cania. This species, the first ammonoid described from the Permian of Queensland, has affinities with forms from the Ural Mountains, which suggest a probable lower Artinskian age.

Ammonoids, which are a key group in the intercontinental correlation of Upper Palaeozoic sediments, have not been described previously from the Permian of Queensland. Etheridge Jr. (1880, 1892) described from the "Permo-Carboniferous system" of Queensland several species that he referred to the ammonoid genus *Goniatites* de Haan, but examination of the relevant specimens in the Geological Survey of Queensland collections has shown that only four are of Permian age and all four are gastropods. The discovery therefore, in the Lower Permian of the Yarrol Basin, of an ammonoid with well preserved suture lines is significant in the correlation of the Queensland Permian with overseas successions.

The single ammonoid was collected during regional mapping of the Monto 1 : 250,000 sheet area by the Geological Survey of Queensland, from the basal beds of the Yarrol Formation in a tributary of Spring Creek, 6 miles east-south-east of Cania. A rich brachiopod assemblage with the ammonoid includes *Strophalosia preovalis* Maxwell, *Linoproductus* cf. *lyoni* Prendergast, *Anidanthus springsurensis* (Booker), *Cancrinella* cf. *farleyensis* (Eth. and Dun), *Terrakea* sp., *Lissochonetes yarrolensis* Maxwell, *Ingelarella profunda* Campbell, and *Grantonia* cf. *hobartensis* Brown. It is similar to the brachiopod fauna from the Yarrol Formation at Yarrol Station, which was regarded by Maxwell (1964) as upper Sakmarian.

Some of the brachiopods that were figured by Etheridge Jr. (1892) came from the Yarrol Formation in Spring Creek, not far from the ammonoid locality.

Other cephalopods collected in Spring Creek during the regional mapping include an indeterminate ammonoid fragment higher in the Yarrol Formation, and a straight nautiloid from the overlying Owl Gully Volcanics.

The Burnett Formation which underlies the Yarrol Formation is dominantly terrestrial in the Cania area, where it is disconformable on the Lower Carboniferous.

Family **PARAGASTRIOCERATIDAE** Ruzhencev, 1951

Genus **URALOCERAS** Ruzhencev, 1936

URALOCERAS CANCELLATUM sp. nov.

(Plate 25, figures 1–4)

Material.—Holotype, F.9060a, b, c, Geological Survey Collection; from locality D158, in tributary of Spring Creek, 100 yards south-east of bridge on the road between Monto and Clonmel homestead; Portion 37, Parish of Clonmel, County of Yarrol. Specimen consists of part of flank of body chamber and approximately one-third of a mature whorl of the phragmocone.

Diagnosis.—Conch large, subdiscoidal, evolute; internal mould strongly lirate, with growth lines on dorso-lateral flanks; suture with ventral prongs and lateral lobes of equal width, and with constrictions of first lateral saddle.

Description.—Conch large, evolute, and subdiscoidal, with wide umbilicus; maximum diameter in excess of 70 mm; flanks gently convex; venter subangular, but partly flattened by external pressure; umbilical shoulder rounded, and umbilical wall short and steep; dimensions of chamber near adoral end of phragmocone—height 30 mm, width 15 mm.

Test thin-shelled, strongly lirate, with lirae strongly impressed on internal mould; lirae 10–12 per 10 mm on ventro-lateral flanks of outer whorls, slightly finer on dorso-lateral flanks; lirae on internal mould as strongly impressed on dorso-lateral flanks as on venter; intervening furrows of same width as lirae; fine transverse striae form shallow sinus on dorso-lateral flanks of internal mould but do not persist ventrally; transverse ornament obliterated on external mould; nodes not developed; constrictions absent in that portion of shell preserved; ornament of innermost whorls unknown.

External suture of five primary lobes and six primary saddles; ventral lobe broad, divided by large ventral saddle; lateral lobes and prongs of ventral lobe of same width, and shaped like ogee arches (pl. 25, fig. 3); first lateral saddle constricted on both sides near base; faint lobation developed on ventral side of pointed umbilical lobe; suture lines broader on lobes than on saddles because of lower inclination of septa to shell surface; internal suture unknown.

Remarks.—The subdiscoidal, widely umbilicate conch and the diagnostic suture indicate reference of this species to *Uraloceras*, within the Paragastrioceratidae, a family of lirate gastrioceratids which ranges almost throughout the entire Permian. Apart from occurrences in New South Wales and Western Australia, *Uraloceras* is virtually restricted to the Ural Mountains region, where it first appears in the upper Sakmarian (upper part of Tastubian horizon of Ruzhencev (1952)), and ranges into the upper Artinskian (Baigendzhinian substage of Ruzhencev (1956)).

Glenister and Furnish (1961) have discussed adequately the relationships between *Uraloceras* and the closely related genera *Paragastrioceras* Tchernow and *Pseudogastrioceras* Spath. Essentially, *Paragastrioceras* and *Uraloceras* have a finely lirate, narrowly umbilicate conch, and a ventral salient of the apertural margin, whereas *Pseudogastrioceras* has a coarsely lirate, narrowly umbilicate conch, and a rounded hyponymic sinus. *Uraloceras* is distinguished from *Paragastrioceras* by

its comparatively poorly developed nodes, and by its sutures in which the ventral prongs and lateral lobes are of equal width. In both *Paragastrioceras* and *Pseudogastrioceras*, the prongs of the ventral lobe are usually conspicuously narrower than the lateral lobes. *Uraloceras* and *Paragastrioceras* are restricted to the Sakmarian and Artinskian, and *Pseudogastrioceras* does not range below the upper Artinskian.

Uraloceras cancellatum compares closely with several species from the upper Sakmarian and lower Artinskian (Aktastinian substage of Ruzhencev (1956)) of the Ural Mountains. The greatest similarity is with larger specimens of *U. complanatum* (Voinova), figured by Ruzhencev (1956, pl. 25, figs. 5, 6) from the Aktastinian substage. This Russian species has a marked constriction of the first lateral saddle and a very faint lobation on the ventral side of the umbilical lobe (Ruzhencev, 1956, text-fig. 62), but is smooth on the internal mould and has scattered constrictions. The young growth stages of *U. complanatum* show prominent transverse ribbing which is absent in the more mature whorls.

Another closely comparable species from the Aktastinian of the Urals is *U. fedorowi* (Karpinsky), as figured by Ruzhencev (1956, pl. 26, figs. 1a, b). Lirae of similar density to those on *U. cancellatum* show on the internal mould, and ribs are absent in the mature whorls. The suture of *U. fedorowi* shows a slight lobation on the ventral side of the umbilical lobe, but lacks the constrictions of the first lateral saddle.

U. limatulum Ruzhencev (1938, pl. 5, figs. 11–15; 1951, pl. 13, figs. 5–7) from the Sterlitamakian horizon (upper Sakmarian) of the southern Urals has affinities with *U. cancellatum*, but can be distinguished by its smaller size, smooth internal mould, finer lirate ornament, shallower umbilical lobe, and absence of constrictions on the first lateral saddle.

U. pokolbinense (Teichert), one of the two ammonoid species described from the Permian of New South Wales, has resemblances to *U. cancellatum* in the sutures. It differs in its less compressed, more evolute shell, and in the presence of scattered constrictions. Apart from poorly impressed traces of lirae on the body chamber, the internal mould of *U. pokolbinense* is smooth. Figures of the suture line of *U. pokolbinense* by Teichert (1954, pl. 7, figs. 1–3, text-fig. 2) show that the constrictions of the first lateral saddle and the lobation on the ventral side of the umbilical lobe are less pronounced than in *U. cancellatum*. *U. pokolbinense* was included originally by Teichert (1954) in *Pseudogastrioceras*, but was subsequently assigned to *Uraloceras* by Glenister and Furnish (1961), on the basis of its diagnostic suture line. Because of the development of a biconvex constriction in the paratype, *U. pokolbinense* was considered by Glenister and Furnish (1961) to be "somewhat transitional" between *Uraloceras* and *Pseudogastrioceras*, in the nature of the apertural margin. *U. pokolbinense* comes from the Farley Formation, the age of which is considered to be late Sakmarian or early Artinskian (Glenister and Furnish, 1961).

Uraloceras irvinense Teichert and Glenister (1952, pl. 4, figs. 2–7) from the Sakmarian Holmwood Shale of the Perth Basin is a small form which does not closely resemble *U. cancellatum*.

From the base of the Middle Bowen Beds at Mt. Britton in the northern Bowen Basin, Whitehouse (1925) identified a paragastrioceratid that he referred to *Girtyites* Wedekind, a junior synonym of *Paragastrioceras*. The specimen could not be located for examination. An unlabelled external mould of a probable paragastrioceratid in the Geological Survey of Queensland collection is preserved in a reddish brown matrix similar to that at Mt. Britton, but is not the specimen identified by Whitehouse (F. W. Whitehouse, pers. comm.). The Geological Survey specimen is strongly ribbed and coarsely lirate, and does not resemble *Uraloceras cancellatum*.

In conclusion, the closest affinities of *U. cancellatum* are with lower Artinskian species from the Ural Mountains and with *U. pokolbinense* from the Farley Formation in New South Wales.

LITERATURE CITED

Etheridge, R., Jr., 1880. Report on a collection of fossils from the Bowen River coalfield and the limestone of the Fanning River, Northern Queensland. *Proc. R. phys. Soc. Edinb.*, 5, pp. 263–328.

———, 1892. *In* Jack, R. L., and Etheridge, R., Jr., The geology and palaeontology of Queensland and New Guinea. *Publ. geol. Surv. Qd*, 92, pp. 1–768.

Glenister, B. F. and Furnish, W. M., 1961. The Permian Ammonoids of Australia. *J. Paleont.*, 35, pp. 673–736.

Maxwell, W. G. H., 1964. The geology of the Yarrol region. Part I. Biostratigraphy. *Pap. Dep. Geol. Univ. Qd*, 5, (9), pp. 1–79.

Ruzhencev, V. E., 1938. Ammonoids of the Sakmarian stage and their stratigraphic significance. *Probl. Paleont., Moscow*, 4, pp. 187–285.

———, 1951. Lower Permian ammonoids of the southern Urals. I. Ammonoids of the Sakmarian stage. *Trav. Inst. paléont. Acad. Sci. U.R.S.S.*, 33, pp. 1–188.

———, 1952. Biostratigraphy of the Sakmarian stage in the Aktyubinsk region of Kazakhstan, U.S.S.R., *Trav. Inst. paléont. Acad. Sci. U.R.S.S.*, 42, pp. 1–87.

———, 1956. Lower Permian ammonoids of the southern Urals. II. Ammonoids of the Artinskian stage. *Trav. Inst. paléont. Acad. Sci. U.R.S.S.*, 60, pp. 1–275.

Teichert, C., 1954. A new ammonoid from the eastern Australian Permian province. *J. roy. Soc. N.S.W.*, 87, pp. 46–50.

———, and Glenister, B. F., 1952. Lower Permian ammonoids from the Irwin Basin, Western Australia. *J. Paleont.*, 26, pp. 12–23.

Whitehouse, F. W., 1925. List of fossil fauna and flora; Nebo district. *Qd Govt Min. J.*, 26, p. 474.

EXPLANATION OF PLATE XXV

All figures natural size

Uraloceras cancellatum sp. nov.

Fig. 1. Lateral view of holotype, F.9060a, b, c (G.S.Q.), showing internal mould of part of phragmocone and body chamber.

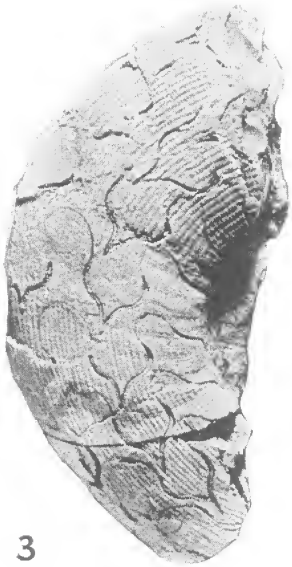
Fig. 2. Ventral view of internal mould of phragmocone of holotype, F.9060a (G.S.Q.), showing depressed shell.

Fig. 3. Lateral view of same, showing suture line, lirae, and growth lines.

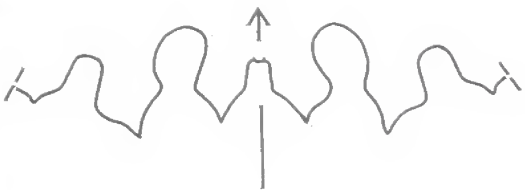
Fig. 4. Suture line of same.

1

2



3



4